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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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ACCEPTANCE OF MANUSCRIPTS

The increase in the volume of pertinent material offered for publication in the Plant Disease Reporter has made it necessary to limit the subject matter and the length of articles accepted. The subject matter should emphasize new things in plant pathology, such as new records of disease occurrence, serious outbreaks and epidemics, conditions affecting development of plant diseases, techniques of investigation including instrumentation, new discoveries in control including new materials and their evaluation. Manuscripts will be limited to 15 double-spaced typed pages. Insofar as possible, material should be presented as graphs rather than tables. Papers cannot be accepted for publication that report routine control experiments, reviews, bibliographies without annotation, results of routine surveys, mere summaries or lists of plant diseases. By following this procedure we hope to continue publishing all articles promptly.

Paul R. Miller

Manuscripts for and correspondence about this publication should be sent to:

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A new root-dipping method of testing potato plants for resistance to ring rot, faster than the previously used seedpiece inoculation, is described by REINER BONDE, ROBERT AKELEY, and DONALD MERRIAM, page 198.

Uniform fungicide trials carried out in Maine, New York, Indiana, and New Hampshire revealed that maneb at 1.5 or 2 pound rates was superior to the standard dosage of tank mix zineb for control of early and late blight of potato, according to GORDON A. BRANDES, REINER BONDE, R. C. CETAS, R. W. SAMSON, and A. E. RICH, page 201.

D. J. deZEEUW, G. E. GUYER, A. L. WELLS, and R. A. DAVIS conducted experiments on the effects on germination and field stand of various fungicides and insecticides, and found that organic fungicides alone or combined with insecticides were superior to mercury materials and to insecticides alone in certain pea, bean, and cucumber seeds, page 213.

J. PALTI reviews the occurrence, distribution, importance and control of Oidiopsis diseases of various vegetable and legume crops in Israel, page 221.

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From a sampling study of nematodes found associated with wheat in north and central Texas, DON C. NORTON concludes that most nematodes are not contributing seriously to poor wheat yields, page 227.

A survey of plant parasitic nematodes in turf nurseries has been made in Georgia by J. M. GOOD, A. E. STEELE, and T. J. RATCLIFFE, page 236.

Of four nematocides tested for control of the potato rot nematode in Wisconsin, only ethylene dibromide resulted in a high level of control when applied as a soil fumigant with a split plow sole application, according to H. M. DARLING, page 239.

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For application of a fumigant directly into the seedbed, DONALD J. MORTON found that granular Nemagon listed into the beds before planting had an advantage over liquid applications in that the need for special equipment and an extra tractor operation was eliminated, page 248.

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JULIUS FELDMESSER, R. V. REBOIS, and A. L. TAYLOR describe a preliminary experimental attempt to eliminate fungi as a possible cause of the symptoms of spreading decline of citrus without eliminating burrowing nematodes also, page 261.

FRUITS AND NUTS (see also under Virus, Nematodes, Miscellaneous)

Six undesirable bud mutations causing fruit abnormalities in apple were investigated by R. M. GILMER and J. EINSET, page 264.

ROBERT H. FULTON submits experimental evidence supporting the hypothesis that resistant varieties of strawberry may transmit the red stele disease organism to susceptible varieties, page 270.

Blast of walnut in California, caused by the organism causing blast of citrus and stone fruits, is reported for what is believed to be the first time by PETER A. ARK and MILTON R. BELL, page 272.

MISCELLANEOUS

PETER A. ARK and JAMES P. THOMPSON predict a useful future for garlic juice and garlic powder in control of numerous bacterial and fungal diseases of economic crops, page 276.

Results of field experiments in southeastern North Carolina from 1955 through 1958 indicated that Terraclor was the most successful of the soil fumigants and fungicides compared for control of crown rot in Dutch iris, according to ROBERT AYCOCK, page 283.

Brief Notes on Plant Disease Occurrence, page 287: Brown spot of soybeans in New Jersey, by R. A. CAPPELLINI. An early record of pear rust in Arizona, by PAUL D. KEENER.

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THE HALF-LIFE CONCEPT OF LONGEVITY OF PLANT PATHOGENS

C. E. Yarwood[1] and E. S. Sylvester[2]

Abstract

Since many, if not most, viruses and other plant pathogens are inactivated at a logarithmic rate, the prevalent idea that total longevity can be stated as a definite time is considered untenable. The half-life or the time for a population to lose one half of its activity, already in limited use, is here proposed as a more correct method of expressing longevity. Methods of calculation and examples are given.

It is customary to refer to the longevity of plant viruses as the time for a sample to lose all its infectivity (3, 7, 22). This useful concept loses much of its significance as measurement becomes more precise. The more accurate, more easily determined, and more widely applicable term "half-life" is here proposed. Half-life is defined as the time for a homogeneous population to lose one half of its activity. The term is already in use in a limited way with bacterial (2), animal (15), and plant viruses (30), and in a universal way with radioactive atoms (8). It is analogous to LD50 or ED50 in toxicology (16), though in the latter case the mathematics are different. It is here proposed that the term be applied to the inactivation of living or life-like things in general.

When a homogeneous population of bacteria (6), plant viruses (21), bacteriophages (1), enzymes (14), or certain multicellular organisms (20) is subjected to unfavorable environment, the individuals die or become inactivated at a logarithmic rate or approximately so. In other words, if the logarithm of the number of survivors of such a population is plotted against time the resulting graph is a straight line. More conveniently, the actual number of survivors on a logarithmic scale plotted against time on an arithmetic scale gives a straight line. This type of reaction is also said to proceed exponentially or as a first order reaction. Algebraically speaking $P_1 = \frac{P_o}{2^{T/t\,1/2}}$ (equation 1) and $t\,1/2 = \frac{T \log 2}{\log P_o - \log P_1}$ (equation 2) when P_o = original population, P_1 = population after time T, T = the interval of observation, and $t\,1/2$ = time interval for half of the individuals to be inactivated or the half-life of the population. There may be many cases where the logarithmic rate of inactivation does not apply and certainly most data on inactivation of living things cannot be shown to proceed in this manner. Whether this is because the organism is not inactivated at a logarithmic rate, because the data were not collected with this in mind, because of experimental error, or for some other reason, is not known; but it seems that the more complete the data the more nearly they approach a logarithmic rate of inactivation.

The observed time for a sample of virus to lose all its infectivity is determined by the size of the sample and the sensitivity of measurement of infectivity as well as by the rate of the inactivation. For example, if a sample consisting of 1000 infective units lost its activity at the rate of one half the infective units per hour and the smallest number of infective units which could be measured was 100, the longevity of the virus would be determined as between 3 and 4 hours. If the size of the sample remained unchanged but the sensitivity of assay were increased so that one infective unit could be detected, the measured longevity of the virus would be increased to between 9 and 10 hours while the real longevity had remained unchanged. Similarly, if the size of the sample were increased to 100, 000 units and the sensitivity remained at one unit, the measured longevity would be between 16 and 17 hours. With calculated or plotted half-life as the criterion of longevity, longevity would remain the same in the above cases though the size of the sample or the sensitivity of the method were changed.

As an example of the use of the half-life method of expressing the longevity of viruses, the data of Bennett (5) for dodder latent mosaic will be used. Bennett found that the number of local lesions formed from a virus sample at 0, 2, 6, 12, 24, 48, and 72 hours after extraction was 93, 87, 93, 41, 5, 2, and 0, respectively. The observed total longevity was between 48

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and 72 hours. The half-life as observed from a graphic plotting of the data would be about 11 hours for the unsmoothed graph and about 8.5 hours for the smoothed graph. Using the data of 0 and 48 hours and calculating by equation 2, the half-life would be

$$\frac{T \log 2}{\log P^{o} - \log p l} = \frac{48 \times 0.301}{\log 93 - \log 2} \text{ hrs.} = \frac{14.4}{1.969 - 0.301} \text{ hrs.} = 8.6 \text{ hours.}$$

Half-lives of some representative plant pathogens, determined graphically or by calculation from available data by the above methods, are given in Table 1.

The use of the exponential equation in connection with insect vectors was suggested by Smith and Lea (23) in an attempt to develop a mathematical rationale to support the concept that the differences between the types of transmission were quantitative rather than qualitative (23, 28), and thus permit a generalized concept regarding some of the properties of viruses as largely a function of virus concentration in the host plants. Perhaps it was this overemphasis on the quantitative aspects of viruses which limited its acceptance by virus workers.

Table 1. Half-lives of some plant pathogens.

Pathogen and condition of exposure	Half-life	Source of information
Prunus virus B, undiluted	38 seconds	Fulton, 1957 (12)
Prunus virus B, diluted in phosphate, 24° C.	3.8 hours	Fulton, 1957 (12)
Prunus virus, diluted in phosphate, 0° C.	75 hours	Fulton, 1957 (12)
Apple mosaic virus, water suspension	5 minutes	Yarwood, 1955 (30)
Tomato spotted wilt virus, suspension at 22°	10 minutes	Samuel and Bald, 1933 (21)
Tomato spotted wilt virus, suspension at 19°	22 minutes	Samuel and Bald, 1933 (21)
Tobacco necrosis virus, dried deposit on leaves	100 minutes	Yarwood (unpublished)
Cronartium ribicola, sporidia	5 hours	Spaulding and Gravatt, 1926 (24)
Dodder latent virus	9 hours	Bennett, 1944 (5)
Urocystis tritici, chlamydospores in soil	25 days	Griffiths, 1924 (13)
Puccinia coronata, uredospores, 10° C	70 days	Forbes, 1939 (9)
Sugar beet curly top virus, dried exudate	±5 months[a]	Bennett, 1935 (4)
Sclerotium rolfsii, sclerotia in soil	1.2 years	Leach and Davey, 1938 (18)
Heterodera schachtii, cysts in soil	1.7 years	Thorne, 1923 (27)
Tobacco mosaic virus, dried deposit on leaves	15 hours	Yarwood, 1957 (31)
Tobacco mosaic virus, dried leaves	±52 years[a]	Johnson and Valleau, 1935 (17)

[a]Specific data unsuitable for calculation of half-lives, but these values are included as examples of long-lived viruses.

Be this as it may, the exponential law has quite general utility when used in connection with describing various types of vector-virus relationships. Under present day concepts, the viruses -- as far as vector relationships are concerned -- are divided into two groups, the nonpersistent and the persistent, depending upon whether or not the inoculative capacity of a group of vectors is lost rapidly or slowly or not at all. More recently, it was suggested (26) that the aphid-borne viruses might be divided into at least three groups, depending upon, among other things, the length of retention exhibited by vectors under conditions of feeding or fasting. Again, in connection with the transmission of virus by mandibulate insects, Freitag (11) has implied that the prolonged retention does not favor a simple mechanical transmission hypothesis. Likewise, the basic arguments in regard to the multiplication of viruses within their leafhopper vectors initially were centered around the length of retention of the capacity to inoculate plants as well as the presence of a latent period. It is possible that all these questions can be clarified by using a concept of exponential rates of increase or decrease of inoculativity rather than maximum or minimums, and thus vector-virus relationships might more properly be defined in terms of differences in rates of gain or loss of certain capacities.

For example, an attempt has been made to distinguish between aphid-borne monpersistent and semipersistent viruses, on the basis of whether or not the capacity to inoculate plants is lost less or more rapidly under conditions of post-acquisition fasting or feeding (26, 28). Here only rates are of comparative value since absolute times can lead to misinterpretations.

The same is true when trying to determine the presence or absence of a latent period in vectors, as well as when trying to determine its duration. Again, it might be more useful to consider such a term as the LP_{50} (Latent Period 50) which would be interpreted as the length of time in excess of the acquisition threshold period, required by a vector population to develop 50 percent of its inoculative capacity.

A few examples might be illustrative. Freitag (10) published data indicating that the beet leafhopper, when serially transferred to a number of healthy plants, without given re-access to a virus source, gradually lost the ability to cause infections. His data (10, fig. 6) would reasonably fit the assumption that the half-life of the virus within beet leafhoppers is approximately 30 days.

Likewise, although Freitag (11) reported that the striped cucumber beetles could retain the squash mosaic virus (as evidenced by the ability to inoculate plants) for a period of 18 days, the data (11, Tables 3, 4, and 5) for this species can be used to give a half-life estimate of approximately 2.2 days. His data on longevity in vitro indicates a half-life of nearer a week.

In connection with the aphid-borne viruses, Sylvester (25) has published data which when interpreted with a half-life concept would indicate a nonpersistent virus (beet mosaic) to have a half-life of about 5 minutes, while the half-life of a semipersistent virus (beet yellows) with the same vector species and the same host plant species was found to be of the order of 8 hours.

For a rapidly increasing population of viruses (29), bacteria (6), or other forms of life, the logarithmic rate also applies; and the rate may be given as $P_1 = \frac{P_o}{2\,T/t_2}$ and $t_2 = \frac{T \log 2}{\log P_1 - \log P_o}$ where t_2= the generation time of the organism or the time for the population to double in numbers. These two latter equations are merely the inverse of 1 and 2.

The unity of the half-life concept for dying bacteria, viruses undergoing inactivation, and disintegrating atoms with the generation time concept for population increases bespeaks its universality of application and for the desirability of using this terminology where applicable in biology. Half-life is considered simpler to determine and easier to interpret than velocity constant (19) which can also be used to accurately specify the rate of all the processes mentioned here.

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VIRUS INFECTION AND HEATING REDUCE SMOG DAMAGE

C. E. Yarwood

Abstract

On Pinto bean leaves infected by tobacco mosaic virus, a zone of uninjured tissue surrounded each virus lesion under conditions where the non-infected portions of the leaves were severely injured by smog. Leaves that had been dipped in water for 5 to 20 seconds at 50° to 55° C showed no smog damage or showed less than unheated leaves.

As indicated by injury to Pinto beans in the greenhouse in Berkeley, smog (1) was worse in October and November of 1958 than it has been at any previous time. While many plants were rendered unfit for experimental work as a result of smog damage, two experimental treatments applied for other purposes and not previously known to affect injury from noxious fumes were observed to reduce smog damage.

Infection with tobacco mosaic virus (TMV) was observed to reduce smog damage on several occasions. The example chosen for illustration (Fig. 1) was a plant seeded October 27, inoculated with TMV on the upper leaf surface at 2 p.m on November 5, and photographed on November 10. Smog damage occurred generally over the lower leaf surface but was absent around each lesion or each group of lesions. This pattern was superficially similar to the inhibition of smog damage (3) around lesions caused by the uridinial stage of the rust, Uromyces phaseoli, also on Pinto bean.

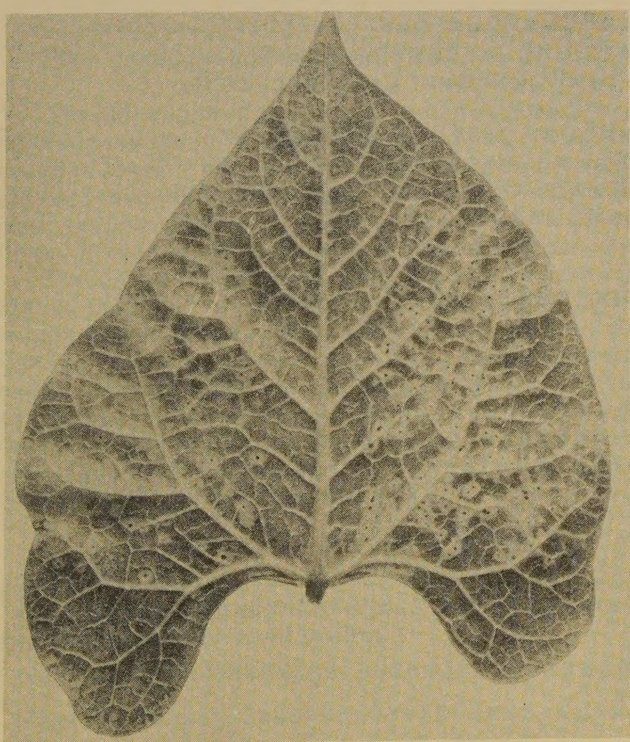

FIGURE 1. Reduction of smog damage by infection with tobacco mosaic virus on the primary leaf of Pinto bean. Photographed November 10, 1958, viewed from the lower leaf surface. The dark color over most of the leaf surface is due to necrosis caused by smog injury. The small dark areas are virus lesions resulting from inoculation of the opposite upper surface. The pale halos around the virus lesions are zones of normal leaf color where smog injury has been prevented.

Absence of smog damage around rust lesions resulting from an inoculation of October 30 was also observed November 10, and the two types of inhibition of smog damage were measured. For four typical rust lesions the average diameter of the sporulating region was 0.54 mm, the average diameter of the mycelial area was 1.32 mm, and the average diameter of zone of inhibition of smog damage was 3.30 mm. For four typical TMV lesions the average diameter of the necrotic area of the lesion was 0.33 mm, and the average diameter of the zone of inhibition of smog damage was 1.9 mm. If we accept the mycelium as the limit of the rust lesion and the necrotic area as the limit of the virus infection, then the distance of inhibition of smog damage beyond the pathogen was 1 mm for the rust infection and 0.8 mm for the virus infection; and the reduction in smog damage by these two infections is probably not significantly different on the basis of these data. Both rust infection (2) and TMV infection (Yarwood, unpublished) cause a localized accumulation of starch around the infection but beyond the pathogen, but this effect is much greater with rust infection than it is with TMV infection, and it is not known if this accumulation of starch is in any way responsible for the reduction in smog damage.

The effect of heating on smog damage was observed October 26 and subsequently on the primary leaves of 10-day plants immersed at 6 p.m. on October 14 in water at 55°C for 5 or 10 seconds (two leaves each), on another set of leaves immersed at 5 p.m., October 15, in water at 55° for 5 or 10 seconds (two leaves each), and on November 10 and subsequently on leaves of 9-day plants immersed at 2 p.m., November 5, at 50° for 10, 15, or 20 seconds (one leaf each). For each of these 11 heated leaves, the corresponding opposite primary leaves of the same plants were unheated and each showed severe smog damage. The heating for 10 seconds at 55° caused some heat injury to the leaves, but this was clearly independent of the smog damage. The protection from smog damage by 55° treatments was complete, and by the 50° treatments only partial, but the 50° and 55° treatments were in different trials. The effect of heating is somewhat surprising in view of the fact that smog damage usually occurs in relatively warm still weather in the fall of the year. The temperature of the experimental heat treatments was, of course, much greater than any to which the plants were exposed naturally.

The exact time of smog occurrence and damage was not known for the virus or rust infection or for the heated leaves.

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UNUSUAL REACTIONS OF TWO SNAP BEAN VARIETIES TO TWO STRAINS OF COMMON BEAN-MOSAIC VIRUS[1]

Leslie L. Dean[2], V. E. Wilson[3], Robert E. Thornton[4], and Owen Agenbroad[5]

Bean (Phaseolus vulgaris L.) varieties vary in susceptibility and resistance to the type strain of bean virus 1 (Marmor phaseoli Holmes) as well as to the variant strain of the virus reported from New York (2) and Idaho (1). Dry bean varieties resistant to the type strain of bean virus 1 may or may not be resistant to the variant strain, but no dry bean variety resistant to the variant strain has been reported to be susceptible to the type strain (1). Snap bean varieties have not been reported to differ in their reactions to the two strains of the virus. Such varieties have heretofore been found to be resistant to both strains if resistant to either.

Inasmuch as visible symptoms incited by the type and the variant strain of common bean-mosaic virus are not distinguishable, a complete set of differential bean varieties would be very helpful in separating the two virus strains.

This has, in part, been possible through the use of field bean varieties, but as yet no variety which combines susceptibility to the type strain of bean virus 1 with resistance to the variant strain is known (Table 1.).

Table 1. Reactions of dry and snap bean varieties to the type and a variant strain of bean virus 1.

Dry bean variety	Snap bean variety	Reaction[a] to bean virus 1	
		Type strain	Variant strain
Great Northern UI-123	Idaho Refugee	R	R
Red Mexican UI-34	Puregold	R	S
None known	Improved Tendergreen	S	R
Common Red Mexican	Bountiful	S	S

[a]R = resistant and S = susceptible.

The full range of resistance and susceptibility to the two virus strains, however, has been found among the snap bean types (Table 1). The snap bean variety Puregold duplicated the reaction of the dry bean Red Mexican UI-34 in being resistant to the type strain of bean virus 1 and susceptible to the variant. Improved Tendergreen reacted in a manner distinct from any other variety of either snap or dry bean inasmuch as it was found to be resistant to the variant strain of bean virus 1 and susceptible to the type strain.

Symptoms of the two strains of common bean mosaic were not always readily distinguishable on Puregold or on Improved Tendergreen, and it was sometimes necessary to make subinoculations to a susceptible variety such as Common Red Mexican or Bountiful, to ascertain whether transmission had occurred. Subinoculations were made by swabbing the carborundum-dusted primary leaves of seedling plants with a cheesecloth pad saturated with crude plant extract obtained from trifoliate leaves of similarly inoculated Puregold or Improved Tendergreen plants. Inasmuch as only the primary leaves were inoculated, recovery of the virus from trifoliate leaves of inoculated plants indicated movement of the virus through the plant even though symptoms did not become apparent.

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DELAYED SYNERGISM OF BACTERIAL BLIGHT AND BEAN MOSAIC ON PHASEOLUS VULGARIS L.[1]

J. D. Panzer[2] and R. L. Nickeson[3]

Summary

Twelve commercial varieties and 36 foreign accessions of the common bean, Phaseolus vulgaris L., were field inoculated with Common Bacterial Blight (CB), Common Bean Mosaic Virus (BMV), and a combination of CB and BMV. Disease readings were taken four times during the growing season. As manifested by foliage symptoms, a synergistic effect of the two pathogens was noted. The effect occurred late in the growing season. The same effect on yields, however, was not apparent. Resistance of a variety to one pathogen was markedly altered in most cases when a second pathogen was also present. In any study and/or screening for resistance to one pathogen it is recommended that the effects of other pathogens on the physiology of the plants tested be considered.

INTRODUCTION

That the susceptibility of a plant to a certain pathogen is sometimes altered if the plant is already invaded by a pathogen has been demonstrated by several workers with respect to fungus pathogens in juxtaposition with fungus pathogens (1, 3, 7, 8, 12, 13, 14), virus pathogens with virus pathogens (9, 10), virus pathogens with fungus pathogens (15) and virus pathogens with bacterial pathogens (4, 5, 6). A more complete review of the literature may be found in (2 and 11).

The virus-fungus effects reported by Yarwood (15) were concerned with a local lesion host for the virus concerned, and the virus-bacterium relationships reported by Hedges (4, 5, 6) with primary effects of the bacterial pathogen virulence. Since no work could be found by the authors relating to virus-bacterium effects on disease severity under field conditions the following work was undertaken.

MATERIALS AND METHODS

Twelve commercial varieties and 36 foreign accessions of the common bean (Phaseolus vulgaris L.) were selected for study. Seeds of the foreign accessions were obtained from the Western Regional Plant Introduction Station, Pullman, Washington. Included in the 48 varieties and accessions were those of bush, semi-vine, and vine growth habit as well as early and late maturing types.

The seeds were treated with Arasan, divided into four lots, and planted in the field June 5. Except in a few cases where seed was inadequate, each accession or variety was planted in a 5 foot row. Each lot or treatment was separated from the others by a double guard row of corn.

Three weeks after planting, two lots were inoculated with Common Bean Mosaic Virus (BMV) by rubbing the leaves of each plant with a mixture of water and macerated bean leaves selected from mosaic infected plants in the greenhouse. The leaves of the field plants had previously been dusted with #600 grit carborundum.

Two weeks later, one of the uninoculated lots and one of the virus inoculated lots were inoculated with Common Blight (CB) of bean (Xanthomonas phaseoli (E. F. Sm.) Dows.) by rubbing a broth-bacteria mixture on the leaves of the plants after they had been dusted with carborundum.

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Thus four treatments were effected: 1) uninoculated check; 2) CB inoculated; 3) BMV inoculated; and 4) CB and BMV inoculated. The purposes of the experiment were to determine whether there was a synergistic effect of BMV plus the CB organism and to determine the level of resistance of the various beans to these pathogens.

EXPERIMENTAL RESULTS

Disease indices for four reading dates are presented in Table 1. These readings are based on a numerical disease scale of 0, 1, 2, 3, and 4 which represent no, slight, medium, severe, and very severe disease, respectively, for either bean mosaic (BM) or common bacterial blight (CB) in the early readings of July 31 and August 20. In the later readings of September 9 and 17, the symptoms of the separate diseases could not be discerned and the numerical indices refer to total disease development (general plant appearance).

Table 1. Average disease indices of 48 varieties and accessions of *Phaseolus vulgaris* L. inoculated with bean mosaic and/or bacterial blight of bean (*Xanthomonas phaseoli* (E. F. Sm.) Dows.).

Treatment	Reading dates					
	July 31		August 20			
	Mosaic	Blight	Mosaic	Blight	Sept. 9[b]	Sept. 17[b]
Uninoculated (check)	.5[a]	1	2	2	2	2
CB	.5	2	2.5	2	2	2
BMV	1.5	1	2	1.5	2.5	2.5
BMV plus CB	1.5	2	2.5	2.5	3	3

[a] Disease Index (Average of 48 varieties): 0 = none, 1 = slight, 2 = medium, 3 = severe, 4 = very severe (approaching necrosis).
[b] Disease indices represent total disease on plant as separate syndromes were not discernible at the late reading dates.

That there is no early synergistic effect of the two pathogens is evident from the data of the July 31 reading. The mosaic reading of the double inoculated plants (1.5) corresponds exactly with that of the mosaic inoculated plants (1.5), and the bacterial blight reading of the double inoculated plants (2.0) with that of the blight inoculated treatment (2.0).

In the August 20 reading, however, a slight synergistic effect may be noted, that is, BMV plus CB (2.5) as compared with BMV alone (2) for mosaic, and BMV plus CB (2.5) as compared with CB alone (2) for common blight. This is more apparent in the later readings of September 9 and 17 where the double inoculated treatment has a disease reading of 3 as compared with 2.5 and 2, respectively, for the treatments of BMV alone and CB alone.

The synergistic effect is strikingly evident when the data are viewed with respect to the percentage of plants in a given treatment having a final disease reading of 4. These data are presented in Table 2.

When the grouped data of all 48 varieties and accessions are considered, it can be seen that 52 percent of the varieties receiving the double inoculation had a disease index of 4. However, only 10 percent of the mosaic inoculated plants had this rating and only 2 percent of the CB inoculated, as was also true for the uninoculated plants. Even when the disease percentages of the single disease treatments are added (10 plus 2) they are far short of the 52 percent found with the double inoculated plants.

The same trend may be noted when the varieties are grouped into seven categories (Table 2) consisting of early, late, bush, semi-vine, vine, commercial varieties or foreign accessions.

The trends noted in Table 1 for the grouped data were also present in the data of the seven types with the exception of the late and semi-vine types where the synergistic effect was not noted until the September 9 and 17 readings.

Although striking in effect upon foliage symptoms, the synergistic effect was not manifested in the yields obtained. The average yields for the various treatments in grams per plant were 13, 10, 16 and 15 for the uninoculated, CB alone, bean mosaic alone and double inoculated treatments, respectively.

Table 2. Percentage plants of seven bean categories with disease index of 4 at final disease reading.

Bean category	Treatments			
	Uninoculated	CB	BMV	BMV and CB
Early	0[a]	7	27	67
Late	3	0	3	45
Bush	0	5	18	64
Semi-vine	5	0	5	45
Vine	0	0	0	17
Varieties	0	0	0	50
Accessions	3	3	15	53
Varieties and accessions	2	2	10	52

[a] Percentage plants with a disease index of 4 (very severe disease or necrotic) at final reading.

With respect to resistance it was found that although 22 accessions appeared resistant (resistant being defined as a disease index rating of 1 or 2) to CB and 17 to bean mosaic in the single inoculation treatments, only five accessions were found resistant when both diseases were present, that is, in the double inoculated plots. The Plant Introduction (PI) numbers of the resistant accessions were 177,501 and 179,008 for those with a disease index of 1; and 181,953, 176,681 and 207,203 for those with a disease index of 2. No commercial varieties were rated as being resistant when inoculated with either pathogen alone or in combination.

DISCUSSION

It is well known that any disease should be considered in terms of the host, the pathogen and the environment. Unfortunately, the environment is usually thought of in terms of humidity, temperature, light and so forth. On the basis of these experiments it appears that a given disease should be considered as a part of the internal environment of the host when the plant becomes infected with a second disease. The usual physical environmental factors (temperature, humidity and light) are known to alter the physiology of a host plant and thus affect the internal environment of that plant. In a like manner it appears that a pathogen may alter the physiology of a host plant in such a way that a second pathogen is affected adversely or beneficially. The fact that one disease can so precondition a host as to affect the establishment and/or development of a second disease is apparent from the delayed synergism noted in this study.

Furthermore, the susceptibility of a given variety may be drastically altered by infection with multiple pathogens. This was evident from the fact that although approximately 40 percent of the varieties and accessions tested appeared to be resistant to CB or BM when singly inoculated, only 5 percent retained this resistance when both diseases were present. It is suggested that synergistic relations may be responsible for the "breakdown" of resistance in the field of varieties found resistant in the greenhouse. In any study and/or screening for resistance, it is recommended that multiple diseases be considered in the internal environment of the varieties to be tested.

That little effect was noted when plant yields were considered is not surprising in view of the fact that the synergistic effect occurred late in the season. Only mature, dry, commercially acceptable beans were harvested. Pod-set in these beans occurred early in the season when all treatments showed a medium disease reading or less (Table 1). A synergistic effect was noted in regard to immature green beans as there were virtually no green immature beans on the double inoculated plots, while moderate numbers were noted on plants receiving the other treatments. No exact determination was made, however, and these results are a product of visual examination only.

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DISEASE RESISTANCE IN THE RUNNER BEAN, PHASEOLUS COCCINEUS L.[1]

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Summary

Six varieties of the runner bean, Phaseolus coccineus L., were involved in tests for disease resistance in conjunction with breeding work at Oregon State College. When tested against 27 virus inocula, including strains of bean yellow mosaic virus, bean common mosaic virus, alfalfa mosaic virus, western ringspot virus, and unidentified forms carried in gladioli, runner bean varieties were infected only by two strains of alfalfa mosaic virus. Tests conducted on a smaller scale also indicated degrees of resistance of these varieties to halo blight, bean rust, and Fusarium root rot.

INTRODUCTION

The runner bean, Phaseolus coccineus L., includes material resistant or immune to several diseases affecting most forms of the common garden bean, P. vulgaris. Because these two species may be hybridized, P. coccineus offers a potential source of disease resistance for commercial bean varieties. For several years a program at Oregon State College has included hybridization of the Blue Lake bean variety of P. vulgaris with P. coccineus lines to obtain resistance to bean yellow mosaic virus (BYMV). In conjunction with the breeding program, runner beans have been tested with strains of BYMV, bean common mosaic virus (BCMV), and other viruses. Their reactions to root rot, rust, and halo blight have been observed on a limited scale. Results of these tests are summarized herein.

REVIEW OF LITERATURE

Many reports of disease resistance or susceptibility in P. coccineus have appeared in the literature. Pierce in 1934 (14) indicated he was unable to infect this species with a strain of BYMV which is now generally considered to be the type strain of that virus. Thomas and Zaumeyer in 1953 (19) reported this species resistant to a strain of BYMV which produced local lesions on tobacco, and Zaumeyer and Fisher (21) failed to infect runner beans with a necrotic lesion strain of BYMV. Rudorf (17) found extreme resistance to both BYMV and BCMV in P. coccineus and reported the successful transfer of resistance to P. vulgaris lines. Data on the inheritance of resistance to BYMV in a cross between this species and P. vulgaris have been published at Oregon State College (2).

White Runner was not infected by BCMV in tests reported by Reddick and Stewart (16) in 1918. However, Nelson (13) reported another variety, Scarlet Runner, to be susceptible to BCMV. Nelson's report was not confirmed by Pierce (14) who reported failure to infect P. coccineus.

Zaumeyer and Harter (22) reported that P. coccineus was not infected by either bean mosaic virus 4 or 4A. All 80 varieties of P. vulgaris tested were susceptible to either systemic or local lesion infection. A similar result was reported by Zaumeyer and Thomas (23) for the pod mottle virus.

Scarlet Runner was found by Burkholder and Bullard (5) to be resistant to fuscous blight (Xanthomonas phaseoli var. fuscans). Jensen and Goss (8) reported that White Seeded Runner was resistant to leaf, pod, and stem inoculations with the halo blight organism (Pseudomonas phaseolicola (Burk. Dows) but developed some systemic infection and halo symptoms when germinated seeds were inoculated. In an extensive test of bean materials in 1925, Rands and Brotherton (15) found that bacterial blight developed to a slight or moderate extent in most of the 57 varieties or strains of P. coccineus included.

Susceptibility to angular leaf spot was reported by Brock (3) in Australia, in 1951.

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Hubbeling (7) reported four varieties of P. coccineus resistant to the blackroot and mosaic forms of BCMV and to BYMV, Nicotiana virus 11 (stipple streak), and four races of Colletotrichum lindemuthianum. Two varieties were resistant to bean rust, Uromyces phaseoli typica, Arth., but all four varieties tested were susceptible to halo blight, Pseudomonas phaseolicola.

MATERIALS

The six lines of P. coccineus involved in the testing program are listed as follows:

Accession 2012 (Butterbean)	Accession 2018 -----
2014 (Barteldes Lima)	2019 (Black Runner)
2016 (Cornwall Giant)	2020 (Scarlet Runner)

All except Scarlet Runner (Associated Seed Growers, Inc.) were obtained from E. M. Meader of the University of New Hampshire under the names listed above. Lines will hereafter be designated by accession numbers only. In many cases only one or two lines were tested. Accessions 2014 and 2019, each a parent in a successful hybrid, were tested most frequently.

TESTS FOR RESISTANCE

Virus

Virus resistance tests were conducted in both the greenhouse and field, Greenhouse inoculations were made by the usual carborundum method when the plants were in the early primary leaf stage. The virus inocula used are listed following. Oregon strains were, in most cases, classified by Dr. F. P. McWhorter on the basis of their behavior on various hosts. Others are listed as received or as tentatively classified.

Designation	Source	Classification
Y	Western Oregon, Blue Lake beans	Bean yellow mosaic virus (BYMV)
W	W. J. Virgin, Cal. Packing Corp.	BYMV
351	Portland, Ore., Blue Lake beans	BYMV
342	Grants Pass, Ore., Blue Lake beans	BYMV
408	Myrtle Creek, Ore., Blue Lake beans	BYMV
179	S. Oregon, Blue Lake beans	Western ringspot, (WRS)[2]
361	Grants Pass, Ore., Ladino clover	Alfalfa mosaic (AMV) + WRS
362	Grants Pass, Ore., Ladino clover	AMV + WRS
BCMV	Western Oregon, Blue Lake beans	Typical bean common mosaic virus (BCMV)
BCMV-1A	L. L. Dean, Twin Falls, Idaho	Burkholder's or N.Y. 15 strain of BCMV
405	Corvallis, Ore., Puregold beans	Severe strain of BCMV
406	Myrtle Creek, Ore., Blue Lake beans	AMV
413	Myrtle Creek, Ore., Blue Lake beans	AMV
A, B, C, D, F, G, H.I, J, K	B. F. Dana, U.S.D.A., bean plots at Prosser, Washington	Unclassified; appeared to be strains of typical BYMV
E	B. F. Dana, U.S.D.A., bean plots at Prosser, Washington	Tests on several hosts indicated AMV
L	R. S. Robertson, Central Washington	Pod blotch virus
M	R. S. Robertson, Central Washington	Node necrosis virus
N	R. S. Robertson, Central Washington	Mottle virus

The Y-strain listed has been used as the primary test strain for BYMV resistance. It causes severe stunting, mottle, and pod distortion in Blue Lake and other susceptible varieties. Western ringspot 179 is a very severe strain that usually kills Vicia faba and many bean varieties (Fig. 1).

[2]A virus causing severe or lethal effects on bean which has been studied and tentatively named western ringspot by F. P. McWhorter. Its classification in respect to other viruses has not been completely clarified.

FIGURE 1. P. coccineus line 2014 (left) and O.S.C. 22 Blue Lake (P. vulgaris) inoculated with Western ringspot virus strain 179.

Data for greenhouse tests of three P. coccineus lines are given in Table 1 to show the number of plants involved and the reaction of the susceptible check varieties. The remaining lines, 2012, 2016, and 2018 were tested with BCMV and BYMV strain W with negative results. Only alfalfa mosaic virus strains E and 406 produced infections in P. coccineus. Symptoms of strain 406 in 2014 were very mild, but infection was confirmed by subinoculation to susceptible Puregold. Unclassified virus strains A through D, and F through K (not in Table 1) produced no symptoms on 2020 (Scarlet Runner), though each infected Dwarf Horticultural.

Table 1. Reactions of P. coccineus lines and check varieties to various virus inocula in greenhouse tests (number infected/number inoculated)

Virus inoculum	2014	2019	2020	Check Varieties: Dwarf Hort.	Puregold	F.M.-1 Blue Lake	F.M.-65 Blue Lake
Y (BYMV)	0/46	----	0/17	11/11	0/18	5/5	----
W (BYMV)	0/18	0/21	0/23	11/11	5/5	11/11	----
351 (BYMV)	0/12	0/11	----	12/12	----	11/11	----
342 (BYMV)	0/12	0/12	----	11/11	----	11/11	----
408 (BYMV)	0/6	0/6	----	5/6	6/6	1/4	----
179 (WRS)[a]	0/12	0/12	----	12/12[b]	----	8/12[b]	----
361 (AMV-WRS)	0/12	0/12	----	12/12[b]	----	9/10[b]	----
362 (AMV-WRS)	0/11	0/12	----	12/12[b]	----	8/12[b]	----
BCMV	0/27	0/27	----	40/40	0/12	0/61	26/28
BCMV-1A	0/7	----	----	6/6	-/6[c]	0/24	----
405 (BCMV)	0/21	0/16	----	22/22	22/22	26/34	----
406 (AMV)	4/6	----	----	----	5/6	6/6	----
413 (AMV)	0/6	----	----	4/6	1/6	5/5	----
E (AMV)	----	----	6/15	14/15	----	----	----
L	0/12	0/12	0/12	4/6	12/12[b]	11/24	----
M	0/12	0/12	0/12	6/6	12/12	16/24	----
N	0/12	0/12	0/12	4/5	12/12	14/24	----

[a]See Figure 1.
[b]Most plants killed.
[c]Mild symptoms confirmed by subinoculation; number plants infected not determined.

Field inoculations, by rubbing, were made with the Y strain of BYMV each year from 1953 to 1956. No infection of P. coccineus lines was observed in these tests. In 1957 a paint sprayer, operated at 30-40 PSI, was used to spray the first trifoliate leaves with a suspension of infective plant juice (Y strain) mixed with carborundum (Table 2). In 1955 P. coccineus and P. vulgaris materials were planted in July near gladioli, a crop known to carry BYMV (12). Severe infection of BYMV susceptible varieties resulted (Table 2). Gladioli were also included in the 1956 and 1957 field plantings, but accounted for less than 10 percent of the infections obtained, apparently because of small aphid populations.

Table 2. Reaction of P. coccineus lines to: (A) Field spray inoculation with Y strain of BYMV, and (B) Natural infection from virus infected gladioli.

Variety	Spray inoculation with the Y strain of BYMV -- 1957: number infected/ number inoculated	Natural infection from gladioli -- 1955: number infected/number grown
2012	---	0/29
2014	0/9	0/25
2016	---	0/23
2018	---	0/28
2019	0/22	0/45
2020	---	0/40
Checks:		
Dwarf. Hort.	25/25	75/127
F. M. -1 Blue Lake	50/58	29/36

Halo Blight

The entire group of six lines was tested against halo blight (Pseudomonas phaseolicola) in the field in 1956. An infective suspension prepared from seed infected bean plants was applied with a paint sprayer at 30-40 PSI when the plants were in the first trifoliate leaf stage. The plots were sprinkler-irrigated every day during the first week after inoculation, and approximately twice weekly thereafter. Seventy-five to 100 plants of each variety were tested.

Discrete primary necrotic lesions developed on all P. coccineus plants. Few halos developed, however, and were much restricted compared to those of Dwarf Horticultural. A few secondary lesions were formed with only an occasional halo late in the season. In Dwarf Horticultural both primary and secondary infection was severe, with large spreading halos, general yellowing, and stunting of the plant. Great Northern U.I. 31 developed primary lesions, mostly lacking halos, with very few secondary lesions.

The tendency to develop only necrotic lesions without halos has been considered to be a form of resistance by Schuster (18) and Jensen and Goss (8). Halo production, however, has been shown by several workers to be affected by temperature and to vary with strains of the pathogen (4, 6, 8, 9). It appears that more intensive tests of P. coccineus varieties with strains of the halo blight organism would be highly desirable.

Bean Rust

In the planting described above, bean rust (Uromyces phaseoli var. typica) developed profusely on every plant of Great Northern U.I. 31 and O.S.C. 22 Blue Lake. No rust could be found on Dwarf Horticultural or any of the six P. coccineus lines. No study was made of the rust strain involved.

Fusarium Root Rot

Tests for resistance to root rot were made by planting seeds dipped in an agar suspension of Fusarium solani f. phaseoli. The fungus strain used was the most virulent of a number of isolates collected from Western Oregon by H. Wiedman. Results from only one field test and one greenhouse test will be reported here, although other tests made in the unpublished thesis work of Azzam (1) produced similar results.

A degree of resistance to Fusarium root rot was observed in P. coccineus materials compared with several commercial varieties of P. vulgaris. Table 3 shows the severity of infection, based on a 0 to 5 rating system with "0" representing a symptomless group of plants. A sample of 20 to 30 plants was examined for each variety.

Table 3. Behavior of P. coccineus and check varieties artificially inoculated with Fusarium solani f. phaseoli.

Variety	Field infection rating	Greenhouse infection rating
O.S.C. 21 Blue Lake	3.5	4.0
F.M. 1 Blue Lake	3.75	---
2014	0.5	3.5
2016	2.0	---
2019	1.25	---
S.R.-1[a]	0.5	0.5

[a]S.R.-1 is a selection made by H. Azzam from 2020 (Scarlet Runner) which has consistently shown better resistance than 2020 or the other P. coccineus lines tested.

The P. coccineus materials have generally shown more resistance, compared with check varieties, in the field than in the greenhouse. In the field test reported in Table 3, the P. coccineus lines developed external browning and soft areas in varying degrees, but no internal symptoms. S.R.-1 showed very little external discoloration or damage to the root system. The Blue Lake checks had severe external symptoms, severe internal browning on many plants, and in some cases the entire hypocotyl was destroyed. Greenhouse infection was severe on 2014 and O.S.C. 21 Blue Lake, while S.R.-1 was again only slightly damaged.

P. coccineus plants develop large and vigorous root systems with enlarged fleshy tap roots (Fig. 2). There is possibly some relationship between this characteristic and a tolerance or resistance to root rot. However, the behavior of S. R.-1 would indicate that there may be substantial differences in resistance not dependent on differences in root vigor. In breeding work

FIGURE 2. Fleshy enlarged taproot of P. coccineus line 2014; approximately three-eighths size.

at Oregon State College greater stress is currently being placed on P. vulgaris lines that appear as resistant as S.R.-1. An attempt will eventually be made to transfer resistance of the P. coccineus material into commercially acceptable types, perhaps with some increased root vigor and size.

DISCUSSION

Results reported here and reports in the literature have shown that a number of lines of runner beans, Phaseolus coccineus, are resistant or immune to a wide range of viruses affecting P. vulgaris. While we employed primarily virus strains from Oregon and adjacent States, other tests cited involved strains from other areas of this country and the world. Degrees of resistance to halo blight, rust, root rot, and anthracnose are also present in varieties of this species. It may thus be of great value as a potential source of breeding material. While the hybridization of runner beans with P. vulgaris is not as simple as P. vulgaris x P. vulgaris crosses, some combinations can be made with good success. Productive hybrids have been obtained from 2014 x Blue Lake, 2019 x Blue Lake, and 2019 x U.S.D.A. B-3076 (bush). Accession 2014 x Blue Lake, after the first backcross to Blue Lake, shows good promise of yielding commercial types resistant to many virus strains occurring in Oregon. Other crosses, such as 2020 x Blue Lake, 2016 x Blue Lake, and 2020 x B-3076 have generally failed because of abnormal or very unproductive F1 generations. F1 plants have been obtained from all crosses attempted, and in most cases produced at least a few viable seeds. It has been necessary to use the P. vulgaris variety as female parent. This and other factors involved in the interspecific cross have been discussed by Lamprecht (10, 11) and Tschermak-Seysenegg (20).

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PRELIMINARY EVALUATION OF SOLANUM SPECIES AND SPECIES HYBRIDS FOR RESISTANCE TO DISEASE

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Summary

Preliminary evaluation for resistance to disease was conducted on approximately 200 selections of 39 Solanum species and 58 species hybrids. Apparent resistance to virus A was found in selections of S. chacoense, S. commersonii, S. demissum, S. herrerae, S. kurtzianum, S. phureja, S. pinnatisectum, S. polyadenium, S. simplicifolium, S. stoloniferum, S. tuberosum and several species hybrids. Resistance to virus X was found in selections of S. acaule, S. cardiophyllum, S. chacoense, S. kurtzianum, S. maglia, S. phureja, S. stoloniferum, S. sucrense, S. tuberosum and seven species hybrids. A number of selections showed some resistance to infection with virus Y by mechanical or aphid inoculation or both. Virus Y did not become systemic in inoculated plants of selections of S. chacoense, S. sambucinum, S. stoloniferum, S. verrucosum, one unidentified species and one species hybrid. Immunity to leafroll was not found in the species and species hybrids. Resistance under controlled conditions greater than that found in the field-resistant Katahdin variety was found in some species and species hybrids. Inoculated plants of selections of S. chacoense, S. maglia, S. phureja, S. polyadenium, S. vernei, four unidentified selections and four species hybrids failed to develop symptoms of Verticillium wilt. Species hybrids inoculated with the spindle tuber virus developed symptoms typical of the disease.

INTRODUCTION

A preliminary evaluation of selections of the tuber-bearing Solanum species (3) and species-hybrids contained in the collection at Sturgeon Bay, Wisconsin for resistance to disease was begun in late 1956. Clonal selections of most of the species and some promising species-hybrids have been included in this study (1). Emphasis was placed on evaluating selections of Solanum acaule, S. cardiophyllum, S. chacoense, S. demissum, S. phureja, S. stoloniferum, and S. tuberosum (andigena). Resistance to disease within these species, though not in these specific selections, has been reported and is now being used in varietal development (2, 4, 6, 7).

Leafroll is considered by some persons to be the most serious disease of the potato on a national scale. Diseases such as mild mosaic, rugose mosaic, spindle tuber, Verticillium wilt and scab are serious production hazards in some potato areas of the United States. Resistance to these diseases was sought in this study to assist in their control through breeding.

MATERIALS AND METHODS

Selections of the tuber-bearing Solanum species (Table 1) and species hybrids (Table 2) used in the preliminary evaluation studies were supplied from the Inter-Regional Potato Introduction Station, Sturgeon Bay, Wisconsin. For the greenhouse studies tubers were kept in cold storage (40° F) well beyond their normal period of dormancy to insure uniformity of sprouting and the maximum production of plants from each tuber (Fig. 1).

The tubers of each selection were planted in 4- or 6-inch pots for germination. When the plants were 1 to 2 inches tall they were separated from the mother tuber and transplanted to 3-inch pots for inoculation, except those intended for inoculation with Verticillium albo-atrum Reinke & Berth. These latter were inoculated and then transplanted to 4-inch pots (10).

As soon as the plants had recovered from the effects of transplanting, they were divided for inoculation with the respective virus as follows: virus X, two plants; virus Y, three plants; leafroll, five plants; and virus A, three plants. Five plants of each selection were included in the Verticillium wilt test. Some selections either failed to produce sufficient plants for each test or the plants died before the completion of the test which explains the lack of complete data for each selection.

[1] Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland and the University of Wisconsin.

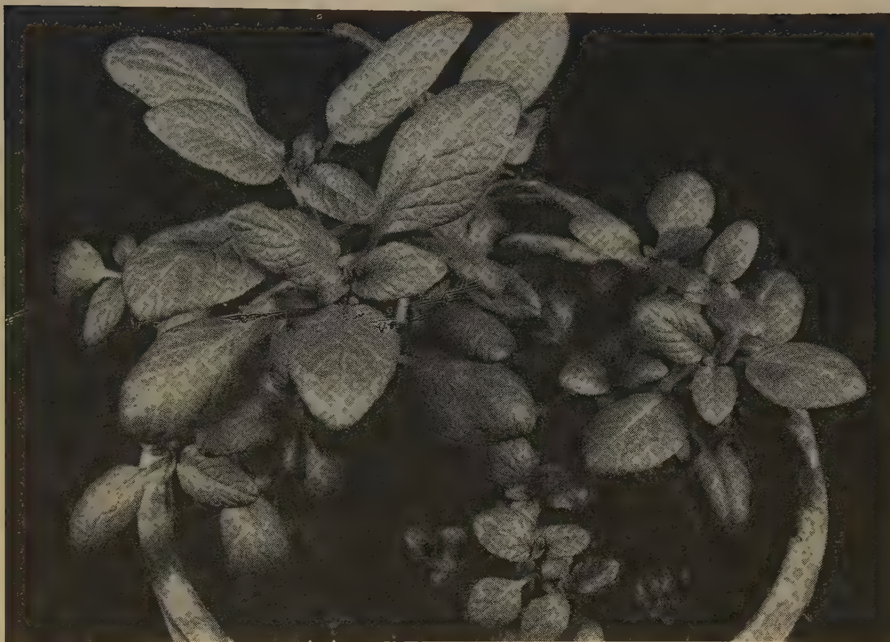

FIGURE 1. Young plants growing from three small tubers which had been held in storage at 40° F for 9 months.

Sources of inoculum for the virus inoculations in these tests were from cultures maintained in the Schultz Potato Virus Collection (8). Inocula for viruses A, X and Y were prepared by macerating infected leaf tissue in a .5 M solution of a phosphate buffer and applying the inocula with a sterilized gauze pad to plants lightly dusted with carborundum. Separate gauze pads were used to inoculate the plants of each selection to prevent the transfer of latent or unidentified viruses. The peach aphid, Myzus persicae (Sulz.) maintained on kale in insect-proof cages was used to inoculate plants with the leafroll virus and to evaluate selections for resistance to aphid infection with virus Y.

In addition to the greenhouse evaluation for disease resistance the species hybrids were tested for resistance to virus Y, leafroll, spindle tuber and scab under field conditions. Five hill lots of each hybrid were planted in each test. Evaluation for scab resistance was conducted in soil which had a long history of being heavily infested with Streptomyces scabies (Thaxt.) Waksman and Henrici. Alternate rows of Katahdin were used as the susceptible controls.

Evaluation of the species and species-hybrid selections for resistance to disease was based on the plant reactions of each in response to inoculation or natural infection in comparison with the reaction of known resistant and susceptible cultivated varieties grown under similar conditions. The plus sign (+) in Tables 1 and 2 connotes susceptibility to plant infection equal to that of the susceptible controls. R indicates less susceptibility to infection than the controls. In some instances the letter R indicates that the presence of the virus could not be demonstrated by subinoculation to the appropriate indexing host.

DISCUSSION OF RESULTS

The data presented in Tables 1 and 2 are of a preliminary nature only and are not intended to imply the results of a final evaluation of the selections for resistance to disease. Rather, the study should be considered as an evaluation of Solanum species for susceptibility to disease. A large number of selections were studied and possible sources of resistance to some major diseases of the potato were found in some of them. The results of the entire study are presented to serve as a guide to those interested in making a more detailed study of the selections possessing resistance to disease.

Table 1. Reaction of some Solanum species to inoculation with some potato viruses and *Verticillium albo-atrum* Reinke and Berth.

PI Number	Solanum species	Reaction[a] to Virus A	Virus X	Virus Y	Leaf roll	Vert. wilt
175396.3	acaule Bitt.		+	+		
195161.1	"		R	+		
205395.1	"		+	+		
205507.1	"		+	+		
205508.1	"		+	+	+	
205520.1	"		+	+	+	+
205521.1	"		+	+		+
208874.1	"		R	+	R	+
208879.2	"	+	+	+	+	+
210029.1	"		R	R		R
210030.1	"		+	+		
210031.1	"		+	+		
210032.1	"	+	+	+		+
217450.2	"		R	+		
230493.1	" var. subexinterruptum			+		
230554.1	"		+	+	R	+
230495.2	acroscopicum Ochoa	+	+	+	+	+
218215	berthaultii Hawkes	+	+	+	+	R
161156	bulbocastanum Dun. var. glabrum			+		
210035.4	canasense Hawkes		+	R	+	
205560.1	capsicibaccatum Card.	+	+	+	+	
210036.2	"	+	+	R	+	R
160370	cardiophyllum Lindl.		+	R	+	+
161120	cardiophyllum		R	+	+	+
195193	" (lanciforme)	+	+	R	R	+
230865	" "		+	R	+	+
WRF 274 (C.3)	"		+	R	+	+
" 276 (C.1)	"		+	+		+
" 278 (C.3)	"		+	+	+	+
" 279 (C.2)	"		+	+	R	+
" 283 (C.3)	"	+	+	R	R	+
175401.1	chacoense Bitt.	R	+	R	+	R
189220.9	"	+	+	+		
189221.8	"	R	+	+	+	R
197758.7	"	+	+	+	R	R
230536	"	R	+	+	+	
133656	" (boergeri)	R	+	R	R	+
230580	" (caldasii)	R	R	+	+	R
133662	" (emmeae)	R	+	+	+	R
133618	" (garciae)	R	+	R	+	R
133663	" "	R	+	R	+	R
133073	" (gibberulosum)		+	+	+	R
133619	" "		+	+		
133664	" "		+	+	+	R
195184.3	" "	R	+	+	+	R
133708	" (parodii)	R	+	R	R	R
133085	" (schickii)	R	+	+	+	R

Table 1, continued

PI Number	Solanum species	Reaction to Virus A	Virus X	Virus Y	Leaf roll	Vert. wilt
133127	chacoense (schickii)					
133709	" "		+	+	+	R
133710	" "		+	+	+	R
133718	" "	R	+	+	+	R
133720	" "	R	+	+	+	R
133722	" "	R	+	+	+	R
189219.8	" "	R	+	R	+	R
209411	" (subtilius)	+	+	+	+	R
217451.4	" "		R	R	+	
230585	" (vavilovii)	+	+	+	R	R
197760	commersonii Dun.	R	+	R	+	R
201846	" (laplaticum)	R	+	R	+	R
225651.4	curtilobum Juz. et Buk.	+	R	+	+	+
160210.1	demissum Lindl.	+	+	+	+	+
160220.2	"	+	+	+	+	+
160221.2	"	R	+	+	+	+
160229.4	"		+	R	+	
160230.4	"	+	+	R	+	+
161118.2	"		+	+	+	+
161134.1	"	R	+	+		
161141.1	"	R	+	+	+	+
161142.1	"	+	+	+	+	+
161149.3	"		+	+		+
161154.1	"	R				
161154.1	demissum	R				
161169.5	"	+	+	+	+	+
161175.4	"	+	+	+	+	+
161179.1	"	+	+	R	R	+
161180.2	"	+	+	R	+	+
161366.5	"	R	+	+	+	+
161367.1	"	R	+	+	+	
161682.3	"		+	+	+	
161714.1	"	+	+	+	+	+
161719.1	"	+	+	+	+	+
161729.4	"		+	R		
161732.1	"	+	+	+	+	+
161769.6	"	+	+	+		
175403.1	"	+	+	+	+	+
175404.1	"	+	+	+	+	+
175411.1	"	+	+	+	R	+
186552.6	"		+	R	+	+
186556.1	"		+	+	+	
201854.1	"	+	+	+		+
205625.1	"	+	+	+	+	+
218047.1	"	+	+	+	+	+
225652.3	"		+	+		+
230487.1	"		+	+	+	+
230488.1	"	+	+	+	+	+

Table 1, continued.

PI Number	Solanum species	Reaction to Virus A	Virus X	Virus Y	Leaf roll	Vert. wilt
230578.1	demissum	+	+	+		+
230579.1	"	R	+	+	+	+
230592.1	"		+	+	+	+
218218.2	famatinae Bitt. et Wittm.	+	+	+	+	R
186559.1	fendleri A. Gray		+	+		
186560.3	"		+	+	+	
211038	gourlayi Hawkes			+		
230503.7	herrerae	R	+	+	R	R
195190	jamesii Torr.		+	R		
133687	kurtzianum Bitt. et Wittm. / (macolae)		+	+	+	+
175435.1	" "	R	R	+	+	
208563	maglia Schlechtd.	R	R	+	+	R
210034	megistacrolobum Bitt. / (alticola)			+	R	
210042.3	neo-hawksii Ochoa	+	+	+		
210046.1	pampasense Hawkes		+	+		
205556.1	phureja Juz. et Buk.		R	+	+	+
195199	" (rybinii)		+	+	+	+
225671.1	" "	+	+	+	+	+
225673.1	" "		+	R	+	+
225675.1	" "		R	+	+	+
225677.1	" "	+	R	+		+
225681.1	" "		+	R	R	R
225683.1	" "		+	+		+
225684.1	" "	+	+	+	R	R
185557.6	stoloniferum (longipedicellatum)		+	R	+	+
205522.1	" "		+	R	+	
195167.6	" (malinchense)	+	+	+	+	+
230465	sucrense Hawkes	R	R	+	+	R
195206	tarijense Ochoa		+	+		
230466	"	+	+	+	+	R
195210	toralapanum Card. et Hawkes		+	+		R
186177.4	tuberosum L. (andigena)	+	+	+	R	R
186180.1	"	R	R	+	R	R
193669	"	+	R	R	+	
194121	"	+	+	+	+	+
194122	"	+	+	+	+	
195211	"	+	+	+	+	R
197932	"	+	R	+	+	+
204341	"	+	R	R	+	R
205622.1	"	+	R	+		R
205623.1	"	+	+	R	+	R
205624.1	"	+	R	+	+	R
209428	"	+	+	R	+	+
209432	"		R	+		
217448	"		R	+		+
230457.5	"	R	+	+	R	+
230499.1	"	R	R	+		R
230500.3	"	+	+	+	+	R
230503.7	" (herrerae)	R	+	+	R	R

Table 1, continued.

PI Number	Solanum species	Reaction to Virus A	Virus X	Virus Y	Leaf roll	Vert. wilt
218223.6	simplicifolium	R	+	+	+	+
218225.2	"	+	+	+	+	R
218226.2	"	+	+	+	+	R
195185	" (gigantophyllum)	R	+	+	R	R
218227.1	soukupii Hawkes	+	+	+	+	R
230502.4	sparsipilum (Bitt.) Juz. et Buk.		+	+	+	+
210039.2	" (lapazense)	+	+	+	+	+
205527.1	stenotomum Juz. et Buk.		+	+	+	+
195214.2	" (yabari)	+	+	+	+	R
160207.1	stoloniferum Schlechtd.		+	R	+	+
160224.2	"		+	+	+	R
160225.3	"		+	R	+	R
160372.2	"		+	R	+	+
161109.4	"	R	+	R	+	+
161124.2	"		R	R	+	+
161125.1	"		+	R	+	R
161158.9	"		R	R	+	+
161160.2	"		+	R	+	+
161161.2	"		+	R	+	+
161281.2	"		+	R	+	+
161364.4	"	+	+	R	+	+
186555.4	" (ajuscoense)		+	+		
230510	" (antipoviczii)	R	+	+	+	+
230477.1	" "	R	+	R	+	+
225685.1	phureja (rybinii)		+	R	+	R
225696.1	" "		+	R	+	+
225679.1	" "		+	+	R	R
225701.1	" "	+	+	+	R	R
225703.1	" "		+	R	R	+
225709.1	" "	R	+	+		+
225710.1	" "	R	+	+	+	+
WRF 340 (C.4)	" (rybinii x rybinii)		+	+	+	R
" 348 (C.3)	" " "		+	+		+
" 359.4	" " "		+	+		+
" 359.9	" " "	+	+	+	+	R
" 360.2	" " "		+	+	R	+
184764	pinnatisectum Dun. / var. heptozygum		+	R	+	+
184774	"		+	+	+	+
230489.2	" "	R	+	R	+	+
161728.12	polyadenium Greenm.		+	+		
230480.2	"	R	+	+	R	R
184773	polytrichon Rydb.		+	+	R	+
210048.2	raphanifolium Card. et Hawkes		+	+	R	
210049.1	"	+	+	+		R
184762.1	sambucinum Rydb.		+	R	+	+
230464.6	sanctae-rosae Hawkes		+	+		
208866.1	simplicifolium Bitt.	R	+	+	+	+
218222.1	"	+	+	+	+	+

Table 1, continued

PI Number	Solanum species	Reaction to Virus A	Virus X	Virus Y	Leaf roll	Vert. wilt
230562	vernei Bitt. et Wittm. Schlechtd.	+	+	R	+	R
195170.1	verrucosum/ var. spectabilis		R	+	+	
161726.2	"		+	R	+	+
161740.4	"		+	R	+	+
161741.2	"	+	+	+	+	+
205390.1	unidentified	+	+	+	+	R
205397.1	"	R	+	+	+	R
205407	"		+	+	+	R
208562	"		+	+	+	R
208876.1	"	+	+	+	+	R

[a] + = susceptible to infection; R = less than 50 percent of inoculated plants developed symptoms or plants failed to develop symptoms and the virus was not detected by subtransfer to an indexing host.

Table 1, concluded.

PI Number	Solanum species	Reaction to Virus A	Virus X	Virus Y	Leaf roll	Vert wilt
208881	"	+	R	+		R
209771	"	R	R	+	+	R
210051.1	"		+	R	+	R
210052.1	"	+	+	+		R
210056.1	"			+	+	R
217456.1	"	+	+	+	+	+
217459.2	"		+	+	+	R
230516	"		+	+	+	
230522	"			R	+	

Table 2. Reaction of some Solanum species hybrids to certain potato viruses and fungi.

PI Number	S. species hybrid	Reaction[a] to Virus A	Virus X	Virus Y	Leaf roll	Spindle tuber	Vert. wilt	Scab
188756	V.K. 37.05 (S. tuberosum)	+	+	+	+	+	+	2/2
188757	V.K. 604.96 " "	+	+	+	+	+	+	2/2
201401	SSRPB 835a (4) (dem.xryb.xtub.)	R	R	R	R	+		4/4
201402	" 1512C (16) "			+	R	+		2/2
201403	" 1553a (12) "	R	R	+	+	+	+	2/2
201404	" 1563c (14) "			+	+	+		1/2
201405	" 1647b (1) "			R	R	+		3/4
201406	" 1506b (9) "			R	R	+	+	2/2
201407	" 1682c (1) "	R	R	+	+	+	+	1/2
201408	" 1488b (1) "	+	R	+	+	+	+	2/4
201914	Introduced from Mexico		+	+	+	+	+	2/3
203899	CB 4414-2 (dem. x dem.)	+	+	R	+	+		2/4
203900	" 4431-5 "	R	+	+	R	+	+	3/4
230901	" 4651-2 "			+	+	+		4/4
230902	" 4737-33 "	+	+	+	+	+	R	4/1
203903	" 4739-58 "	+	+	+	+	+	R	3/3
203904	" 43154-5 "	+	+	+	R	+	+	3/3
203905	" 44158-4 "	+	+	+	R	+	R	3/3
203906	" 46147-30 "	+	+	R	+	+	+	2/4
205385.1	Brv A. S. tuberosum	+	+	R	R	+	R	2/1
208318	A 1494 (pedigree lost by donor)	+	+	+	+	+	+	2/2
208319	A 1680 " " "	+	+	+	+	+	+	
208323	C68 (Ackersegenx9098)305xFlava		+	+	+	+	R	3/3
208324	C111[a](Erdgoldx9089) x Flava			+	R	+		2/4
208325	C139(Allerfruheste Gelbe x9089)Flava	+	+	R	R	+	+	2/3
208326	C199(Ackersegen x 9089)401 x Flava	+	+	+	R	+	+	3/4
208327	C245(") "	+	+	+	+	+	R	3/4
208328	C298(") "	+	+	+	R	+	R	2/4
208329	D148(Aquila x(Erdgold x 9089) 44	+	+	+	R	+	R	2/4
208330	D151 " (") "	+	+	+	R	+	R	2/4

a + = susceptible to infection; R = resistance to infection or plants failed to develop symptoms and the virus could not be detected by subtransfer to an indicator host; 2/2 = numerator indicates tuber area coverage and denominator indicates lesion type on a scale of 0 to 5 in severity of disease.

Table 2, concluded.

PI Number	S. species hybrid	Reaction to Virus A	Virus X	Virus Y	Leaf roll	Spindle tuber	Vert. wilt	Scab
208331	D156 " " "	+	+	+	R	+	R	3/3
208336	D542 Aquila x Flava	+	+	+	R	+	+	
208340	F558 B 150 x Aquila	+	+	+	R	+	R	2/2
208343	F 672 Aquila x Y 73	+	+	+	R	+	+	2/3
208344	F 754 " x Y 202	+	+	+	R	+	R	1/2
208349	F 1158 (pedigree lost by donor)	+	+	+	R	+	+	
208350	F 1279 " " "	+	+	R	+	+	R	1/1
208353	F 1902 " " "		+	+	+		+	1/1
210062	Argentina S. tuberosum	R	+	+	+	+	R	1/1
210063	" "	R	R	+	+		+	3/2
210064	" "		+	+	+	+	R	3/3
210065	" "		+	R	R	+	R	3/3
215617	SSRPB 1661b (7)(dem.xryb.xtuber)	R	R	R	+	+	R	3/2
215619	" 2070 (31)(dem.xryb.xtub.)	R		+	+	+	+	2/1
215620	" 2070 (50) "	+		R	+	+	+	1/2
215622	" 2070 (64) "	+	+	+	+	+	+	1/1
215623	" 2070 (69) "	+		+	+	+	R	1/1
217391	Skerry Champion x Shamrock	+	+	+	R	+	R	3/4
222943	Seedling (Cockerham's 1591b (9)		+	R	R	+	+	3/3
222945	Claymore x Shamrock	R	+	+	R	+	+	2/2
222947	Southesk x Pepo		+	R		+		1/2
222948	" x "	R	+	R	R	+	R	1/3
222950	" x Shamrock		+	+	R	+	+	3/2
222952	Imperia (selfed)	R	+	R	R	+	+	2/2
222680	Seedling 11-79 (Australia)			R	R			
230659	WTT 52-4-9 (andig.var.woelung x tub) x tub.	R	R	+	R	+	R	2/1
230660	" 52-6-2 " "	+	+	+	R	+	+	
230662	" 52-6-9 "		+	+	R	+	+	2/1
	Katahdin	R	+	+	+	+	+	3/3

Virus A

One-hundred fourteen selections of 28 species (Table 1) and 43 species hybrids (Table 2) were mechanically inoculated with a crinkle strain of the virus. Thirty days after inoculation, plants which failed to develop symptoms typical of the disease were indexed on the virus A indicator host S. demissum PI 175404 (9). Selections of the following species were resistant to infection: S. demissum PI 161134.1; 161141.1; 161367.1 and S. sucrense PI 230465. Virus A could not be detected in inoculated plants by subinoculation to the indicator host of the following species and species hybrids: S. chacoense PI 175401.1, 189221.8, 230536, 133656, 230580, 133662, 133663, 195184.3, 133708, 133085, 133710, 133718, 133720, 133722, 189219.8; S. commersonii PI 197760, 201846; S. demissum PI 160221.2, 161154.1, 161366.5, 230579.1; S. herrerae PI 230503.7; S. kurtzianum PI 175435.1, 208563; S. phureja PI 225709.1, 225710.1; S. pinnatisectum PI 230489.2; S. polyadenium PI 230480.2; S. simplicifolium PI 208866.1, 218223.6, 195185; S. stoloniferum PI 161109.4, 230510, 230477.1; S. tuberosum (andigena) PI 186180.1, 230457.1, 230499.1; unidentified species PI 205397.1, 209771, and species hybrids PI 201401, 201403, 201407, 203900, 210062, 210063, 215617, 215619, 222945, 222948, 222952, and 230659.

Virus X

Two-hundred one selections of 35 species (Table 1) and 48 species hybrids (Table 2) were indexed on Gomphrena globosa L. for natural infection with virus X. Of these, 127 were not infected. These were inoculated with a virulent strain of the virus and 30 days afterward, each surviving plant was indexed on G. globosa. The presence of the virus was not detected in plants of the following selections: S. acaule PI 195161.1, 208874.5, 210029.1, 217450.2; S. cardiophyllum PI 161120; S. chacoense PI 230580, 217451.4; S. kurtzianum PI 175435.1; S. maglia 208563; S. phureja PI 205556.1, 225677.1; S. stoloniferum PI 161158.9; S. sucrense PI 230465; S. tuberosum (andigena) 186180.1, 193669, 197932, 204341, 205622.1, 205624.1, 209432, 217448 and 230499.1 and species hybrids PI 201401, 201403, 201407, 201408, 210063, 215617, 230659.

Virus Y

Two-hundred eight selections of 40 species and 58 species hybrids were mechanically inoculated with a common strain of virus Y in the greenhouse. Most of the species selections and all of the species hybrids were evaluated for resistance to aphid infection with the virus under similar conditions. Some of the species hybrids were reported to be resistant to virus Y, and these were placed in the virus-Y-resistance-test plot in the field. Ten to 15 viruliferous aphids were placed on each plant in the greenhouse, and about 25 per plant were used in the field test. Nicotiana tabacum L. var. Samsun was used as the indexing host.

Fifty-two selections (Tables 1 and 2) showed some resistance to infection either to mechanical or aphid inoculation or both. Nineteen selections (S. chacoense PI 175401.1, 133663, 217451.4; S. sambucinum PI 184762.1; S. stoloniferum 160207.1, 160225.3, 160372.2, 161109.4, 161124.2, 161158.9, 161160.2, 161161.2, 161281.2, 186557.6; S. verrucosum 161726.2, 161740.4; unidentified species PI 210051.1 and species hybrid 222943) failed to become systemically infected either by aphid or mechanical inoculation.

Leafroll

One-hundred sixty-four selections of 33 species and 57 selections of species hybrids were evaluated for resistance to leafroll under greenhouse conditions. The species hybrids were also included in a test for resistance to infection under field conditions. Ten viruliferous aphids were placed on each plant in the greenhouse and approximately 25 on each plant in the field test. Physalis floridana Rydb. was used as the indicator host for detecting the efficiency of aphid inoculation and indexing symptomless plants (5).

One or more plants of all selections included in the tests became infected with the leafroll virus. However, 55 selections (Tables 1 and 2) showed greater resistance than the field-resistant Katahdin under controlled conditions. All selections included in the field test became diseased.

Verticillium Wilt

One-hundred sixty-five selections of 30 species and 49 species hybrids were inoculated for resistance to Verticillium wilt. The young plants (Fig. 1) were pulled, roots washed under tap water and momentarily immersed in a 14-day-old solution culture of V. albo-atrum, then transplanted to 4-inch pots (10). Greenhouse temperatures were maintained at 22° to 24° C. Criteria for evaluating host resistance were the appearance of symptoms and the relative severity of the disease.

Symptoms appeared, but did not progress above the lower three leaves on 69 selections of the species (Table 1) and 21 species hybrids (Table 2). Symptoms failed to develop on the following selections: S. chacoense PI 197758.7, 133618, 133663, 209411; S. maglia PI 208563; S. phureja PI 225681.1; S. polyadenium PI 230480.2; S. vernei PI 230562; unidentified species PI 205390.1, 205407, 208881, 210056.1 and species hybrids PI 203902, 210065, 215617, 217391.

Spindle Tuber

Only the species hybrids were evaluated for resistance to the spindle tuber disease. Each selection was planted in the field, and when the plants were 10 to 12 inches tall they were vigorously switched with spindle-tuber-infected foliage of potato seedling 41956. The appearance of foliar symptoms during subsequent growth and the development of characteristic tuber symptoms at harvest on all the selections indicated that they were susceptible to the disease.

Scab

The species hybrids (Table 2) were included in the scab resistance tests. Attempts have not been made to assay the strains of S. scabies in the test plot. However, similar tests have been successful in determining relative levels of scab resistance among potato varieties. Number designations were used to indicate the surface area covered and the pustule type in evaluating the relative resistance of each selection as follows: surface area covered, T = less than 1 percent, 1 = 1 to 20 percent, 2 = 21 to 40 percent, 3 = 41 to 60 percent and 4 = 61 to 80 percent; pustule type, 1 = small and superficial, 2 = larger but superficial, 3 = large, rough pustules, 4 = large pustules but shallow, and 5 = large, deep pustules.

Results of the scab resistance test indicate a number of selections which were not as badly diseased as the susceptible Katahdin. These selections may prove fertile sources of resistance to this disease as well as others since, under some conditions, they appear to possess resistance to one or more diseases (Table 2).

Apparent resistance to two or more diseases is present in selections of a number of species, particularly, S. chacoense, S. phureja, and S. tuberosum (andigena). Several species-hybrids appear to be fertile sources of resistance to two or more diseases for the development of multiple-disease-resistant potato varieties.

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CONTROL OF CONTACT TRANSMISSION OF TOBACCO MOSAIC VIRUS WITH MILK[1]

W. W. Hare and G. B. Lucas

Abstract

Contact transmission of tobacco mosaic virus (TMV) was prevented or markedly reduced by the use of milk or some milk products. Control was obtained in the greenhouse on pepper, tomato, and tobacco, and in the field on tobacco by spraying transplants with either homogenized, canned or dried skim milk within 24 hours prior to inoculation with TMV.

INTRODUCTION

Although many fungal and bacterial diseases have been successfully controlled with chemical sprays or treatments, there have been no reports of practical control with chemicals of a plant disease caused by a virus. Chester (1) in 1934 stated that milk, and some other substances tested, inhibited infectivity of TMV through decreasing the susceptibility of the host. Later, Johnson (5) showed that milk, and several other materials, mixed with virus inoculum prevented TMV infection. He referred to similar results with milk and several other plant viruses and considered the effect due to inactivation of the virus. Fulton (4) in 1943 obtained similar results. Cook (2) mentioned that spraying plants with milk reduced infection on greenhouse tomatoes in England. Crowley (3) in 1958 reported that tomato growers in England, New Zealand, and Australia had attempted to control TMV by spraying with dilute skim milk, as the result of a press release in Great Britain. However, Crowley further reported no control in experiments to test this practice and that although skim milk contained a substance which reduced the infectivity of TMV to Nicotiana glutinosa, this substance was not a virus-inactivator but "a substance which inhibits the infection of N. glutinosa by tobacco mosaic virus."

MATERIALS AND METHODS

At Raleigh, North Carolina greenhouse experiments were conducted using Dixie Bright 101 flue-cured tobacco plants about 4 inches tall when inoculated. A TMV-infected tobacco leaf (about 1 inch x 2 inches) was placed in about 10 ml of 1 percent K_2HPO_4 and thoroughly ground in a mortar. Approximately 1 ml of the resulting homogenate was added to 50 ml of 1 percent K_2HPO_4 and used as inoculum. Ten tobacco plants were sprayed with about 30 ml of homogenized fresh milk. Approximately 30 minutes after spraying, one leaf of each plant was rubbed with a cotton swab saturated with TMV inoculum. Mosaic symptom readings were taken 10 to 14 days after inoculation.

In greenhouse experiments conducted at State College, Mississippi Early California Wonder pepper and Manalucie tomato plants from 4 to 8 inches tall were inoculated with TMV. TMV inoculum was obtained by grinding young leaves of infected tomato without buffer or dilution. Fingers were dipped in the extract and the three youngest leaves or the basal portions of the stems of test plants were then rubbed lightly. Ten plants were used in each treatment. Grade A milk, powdered milk solution, or an equal mixture of the two were sprayed on test plants before or just after inoculation. Notes on virus symptoms were taken at from 14 to 25 days after inoculation.

Field experiments in North Carolina were conducted at five different locations with Coker 187 or Coker 187-Hicks tobacco as test plants: Usually each treatment consisted of two replications of 50 plants each. The transplants were sprayed within 1 hour of pulling at the rate of 5 gallons per 100 square yards with either homogenized, condensed or dried milk. The latter two were diluted to the concentration of homogenized milk. The plants were inoculated with TMV by pulling the plants with contaminated hands. Prior to pulling, the hands were rubbed with leaves of TMV infected plants. In one test, the plants were sprayed with milk 24 hours before inoculation. Disease readings were taken 2 and 4 weeks after transplanting.

[1]Journal Article No. 771, Mississippi Agricultural Experiment Station, State College, Mississippi; and Journal Article No. 982, North Carolina Agricultural Experiment Station, Raleigh, North Carolina.

Table 1. Percentage infection by TMV rubbed on leaves of pepper, tomato and tobacco plants sprayed with milk.

Treatment	Pepper[a]	Tomato	Tobacco
Uninoculated	0	0	0
Unsprayed inoculated	95	90	100
Pre-sprayed inoculated[b]	10	10	0
Post-sprayed inoculated[c]	75	60	60

[a]Average of one trial with Grade A milk and one trial with equal parts Grade A and powdered milk.
[b]Plants sprayed and allowed to dry.
[c]Plants sprayed immediately after inoculation.

Table 2. Percentage infection by TMV rubbed on stems of pepper and tomato plants when fingers were dipped in virus extract, then in milk.

Host and treatment	Uninoculated control	Inoculated controls: Leaves	Inoculated controls: Stems	"Dip" stems[a]
Pepper				
Grade A	0	90	60	0
Powdered	0	90	50	0
Tomato				
Grade A	0	90	90	15

[a]Fingers dipped in virus extract, then in milk, and stems rubbed.

Table 3. Effect of spraying with milk on the percentage infection by TMV on tobacco transplants[a].

Milk treatment	A: 2	A: 4	B: 2	B: 4	C: 2	C: 4	D: 2	D: 4	E: 2	E: 4
Unsprayed	85	94	29	47	84	97	59	80	30	30
Homogenized milk	39	94	8	19	16	30	1	8	1	1
Dried milk	24	92	2	11	32	54	-	-	-	-
Canned milk	39	93	20	34	26	43	-	-	-	-
Uninoculated	0	26	0	0	0	0	0	0	1	1

(Columns: Location A–E; Weeks 2 and 4.)

[a]The plants were sprayed with milk, then inoculated with TMV by pulling them with TMV-contaminated hands.

RESULTS

Spraying young tomato, pepper, and tobacco plants with milk prior to inoculation markedly reduced infection by TMV (Table 1). Spraying just after inoculation gave little control (Fig. 1). Infection of pepper when the basal portions of the stems were rubbed with the virus extract averaged 50 percent; tomatoes inoculated in this manner averaged 70 percent infection. Spraying the stems with milk and allowing the residue to dry before rubbing reduced infection in both cases to 10 percent. Milk caused no visible injury to any of the test plants.

Infection of pepper plants with stems sprayed with milk and inoculated as soon as dry, 24 hours later, and 48 hours later, averaged 10, 10, and 20 percent, respectively. Tests were also made in which the fingers were dipped in virus extract, then in milk, and the plant stems were rubbed. Infection of pepper was reduced from about 50 percent to 0 percent and in tomato from 90 percent to 15 percent (Table 2).

FIGURE 1. Early California Wonder pepper plants inoculated with TMV by rubbing the three top leaves with virus extract. Left to right; uninoculated control, inoculated control, sprayed with Grade A milk before inoculation, and sprayed with milk just after inoculation.

Spraying tobacco transplants with milk before pulling them with TMV-contaminated hands greatly reduced virus infection in field tests (Table 3). At location A, the amount of inoculum used was much greater than in the other tests. In addition, secondary spread of the virus undoubtedly contributed to the limited control in this test as indicated by the 26 percent of infected plants in the uninoculated plots.

In one test, plants were sprayed with homogenized milk 24 hours before handling them with TMV-contaminated hands. None of the plants sprayed with milk exhibited mosaic symptoms; whereas, 30 percent of the non-sprayed plants showed mosaic symptoms after 2 weeks.

DISCUSSION

In these experiments, plants of all three crops were manipulated to simulate the handling of plants in pulling, transporting, and transplanting to the field. The marked reduction in number of plants showing symptoms indicates that milk may be useful in the prevention of manual spread of tobacco mosaic virus in such operations when infected plants are present in the seed bed. Powdered milk solution and whey appear to be as effective as whole milk. Therefore, costs of materials should be low. The plants can be sprayed but some form of dipping of the operator's hands may also be effective. Earlier workers (4, 5) have shown that the inactivation of the virus by milk applies to plant viruses other than TMV. Possibly there are other viruses in which the prevention of manual spread by the use of milk may be useful.

The question arises, also mentioned by Johnson in 1941, as to the effect of milk on animal viruses. If milk or substances in milk can inactivate animal viruses, perhaps some adaptation of the plant protection experiments given here can be made. Air-or droplet-borne animal viruses could possibly be inactivated by a film of milk, or the active substance in milk, before susceptible tissues are reached.

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THE OCCURRENCE OF CURLY-TOP IN VIRGINIA

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During a routine inspection of tobacco fields in Pittsylvania County, Virginia, a tobacco plant was found that exhibited virus symptoms (Fig. 1) similar to those previously observed by the senior author in Kentucky in 1953 and in Wisconsin in 1954. Subsequently, other tobacco plants with similar symptoms were received at the Bright Tobacco Disease Research Station at Chatham and at the V. P. I. Plant Disease Clinic at Blacksburg. These specimens arrived from several areas. In addition to Pittsylvania County, typical specimens were received from Lunenburg, Appomattox, Franklin and Charlotte Counties. In most fields only single plants were observed; however, three diseased plants were found in a 1-acre field in Lunenburg County, and six in a 3-acre field in Franklin County.

FIGURE 1. Curly-top symptoms on flue-cured tobacco.

The occurrence of curly-top in tobacco in the United States has been reported in Maryland by Morgan and McKinney (2), in Kentucky by Valleau (4), and in Wisconsin by Fulton (1). Recently in Florida, Simons and Coe (3) reported the transmission of pseudo curly-top virus of tomatoes by a treehopper.

In June, a tomato specimen was received at the V. P. I. Plant Disease Clinic from Hanover County with symptoms typical of curly-top as it occurs in the Western United States. The leaves at the top were small and the lower leaves curled. A slight purplish cast was quite evident on the upper leaves. The foliage was somewhat stiff and leathery, with a peculiar dull yellowing or bronzing of the entire plant. Unfortunately this specimen was lost before putting in the greenhouse by being stored too long in the refrigerator at Chatham.

The symptoms of curly-top on tobacco are striking when observed in the field. If the infection occurs early in the season, the plant remains stunted and makes very little terminal growth. Leaves on infected plants turn downward and inward. The surface of the leaves take on a rugose, warty appearance and the margins of the leaves roll under, causing the plant to resemble curly kale. In one field, two infected plants were observed that were unusually yellow, but apparently no plants were dying or dead as a result of the disease.

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Five virus-infected plants were removed from the field and brought into the greenhouse for further study. Three of these plants appeared to "grow out" of the symptoms of curly-top during the summer, while the other two remained unchanged.

On the basis of symptomatology only, this disease appears to be the same as the one observed in Kentucky and Wisconsin on tobacco, and the causal virus is tentatively being identified as the sugar beet curly-top virus. No attempt has yet been made to transmit the virus mechanically or by insect vectors.

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THE OCCURRENCE OF RUBBERY WOOD VIRUS OF APPLE IN NEW YORK[1]

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Summary

Rubbery wood virus of apple, previously unreported in the United States, was found in the apple rootstock clone EM I. Rubbery wood symptoms developed on the indicator variety Lord Lambourne propagated directly on rooted shoots taken from the mother stools. Symptoms developed during the second year following propagation. The incidence of infected EM I mother stools was only 6 percent, a fact suggesting that natural spread in the Geneva stool block is either non-existent or extremely slow.

Rubbery wood virus is relatively common in both scion and rootstock clones of apple in England (1, 3) and is also very common in the apple variety Golden Delicious in the Netherlands (2). The virus has not previously been found in the United States, although Posnette and Millikan (4) have reported the occurrence of an apple disorder in Missouri that resembled rubbery wood. The purpose of the present paper is to record the occurrence of rubbery wood virus in an East Malling clonal apple rootstock (EM I) in New York.

HISTORY OF THE GENEVA EM APPLE ROOTSTOCK CLONES

A partial series of the EM apple rootstock clones, comprising numbers I through XVI, inclusive, was received directly from the East Malling Research Station in 1928. These plants were established in the field and, in 1931, rooted shoots of the various individual clones were selected and transplanted in a stool block. The stool block thus established in 1931 is still supplying rooted shoots at the present date. None of the stool plants in the stool block has ever been budded or grafted with scions of an apple variety. All propagation or experimental manipulation with the EM clones has been carried out only on rooted shoots removed from the mother plants in the stool block and transplanted elsewhere.

INDEXING PROCEDURE

A rooted shoot from each individual mother plant in the stool block was lined-out in the nursery in the spring of 1956. The rooted shoots were obtained from clones EM I, II, VII, IX, XII, XIII, and XVI. Each surviving shoot was budded in August 1956 with a bud of the indicator variety Lord Lambourne (East Malling indicator clone). The 1-year budlings resulting from this propagation were headed back to a height of 30 inches at the end of the 1957 growing season. Observations for the presence of rubbery wood and apple mosaic were made both in 1957 and 1958.

RESULTS

None of the Lord Lambourne trees propagated on rooted shoots of clones EM II, VII, IX, XII, XIII, and XVI developed symptoms of rubbery wood or apple mosaic in 1957 or 1958. Of the 51 rooted shoots of clone EM I representing the 51 mother plants of this clone in the stool block, 50 produced Lord Lambourne trees in 1957. None of these trees evidenced symptoms of apple mosaic or rubbery wood in 1957 when they were 1-year budlings. However, in 1958, three of the Lord Lambourne trees propagated on EM I rooted shoots developed characteristic symptoms of rubbery wood. These three trees had been propagated on rooted shoots derived from stool plants 36, 41, and 43.

The affected trees were slightly stunted in growth, and their branches and trunks were very definitely rubbery when touched or bent. In each case the side branches developing from the main trunk showed the characteristic "bottle-neck" growth habit associated with rubbery wood, that is, thickening at and near the point of origin with an abrupt and pronounced taper of the

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[1] Approved by the Director as Journal Paper No. 1142, New York State Agricultural Experiment Station, Geneva, New York.

distal growth. The 2-year wood of the trunks was of a soft, cheeselike texture when cut with a pruning knife.

The affected trees were observed in June 1958 by L. C. Luckwill of the Long Ashton Research Station, Bristol, England, and the diagnosis of rubbery wood confirmed.

DISCUSSION

In England, Posnette and Cropley (3) found the incidence of rubbery wood virus in clone EM I to be 83 percent (100 stools tested). In contrast to this high incidence in England, only three stools of the 50 indexed (6 percent) of the Geneva clone of EM I were found infected in the present study. Since the Geneva EM I clone was received very shortly after the initial distribution of the EM clonal series by the East Malling Research Station, it is evident that the EM series was relatively free of rubbery wood virus in 1928. There is no evidence of infection with this virus in the numerous stools of EM II, VII, IX, XII, XIII, and XVI which were tested, and a very low incidence in EM I. It is not improbable, in fact, that the three infected stools of Geneva EM I may all have been derived from a single infected plant received in 1928, although this possibility cannot now be demonstrated. In any case, it is apparent that very little, if any, spread of rubbery wood virus has occurred in the Geneva EM stool block since it was established in 1931.

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DEPARTMENTS OF POMOLOGY AND PLANT PATHOLOGY, NEW YORK STATE AGRICULTURAL EXPERIMENT STATION, GENEVA, NEW YORK

OCCURRENCE OF STRIPE RUST IN MINNESOTA IN 1958[1]

James D. Miller and J. J. Christensen[2]

Stripe rust, Puccinia glumarum (Schm.) Eriks. & E. Henn., was found in Minnesota for the first time on record on June 17, 1958, by E. B. Hayden. Two pustules were found in a winter wheat field near Stewart, McLeod County, in the central part of the State. In a later survey in this area no further stripe rust was observed.

In southern Minnesota, during the last week of July, traces of stripe rust were found on the durum varieties Langdon and Ramsey in experimental plots at Waseca and on Khapli and several durums in plots at St. Paul and Rosemount.

In plots at Morris, in the west-central part of the State, Hayden found traces of stripe rust on Mindum and Langdon on July 13. By July 24 it was common on several durum varieties. On July 30, Miller observed it on nine varieties of durum and two varieties of common wheat. The number of lesions per leaf varied from 1 to 6; and rust prevalence was 50 to 60 percent on L.D. 410 and L.D. 407, the most severely infected varieties. Traces of stripe rust also were found on bread wheat lines derived from a Frontana-Thatcher cross.

By late July stripe rust was prevalent on durum wheats in the plots at Crookston, in northwestern Minnesota. Of 14 varieties grown, 8 were severely rusted, with 60 to 100 percent of the leaves infected. The most susceptible named varieties were Langdon, Yuma, and Mindum. No infection was found on Sentry, Ramsey, or Towner. In two commercial fields of durum in the same vicinity, stripe rust was 25 and 100 percent prevalent, respectively. On August 1 in the plots at Crookston stripe rust was 5 to 20 percent prevalent on derivatives of a Frontana-Thatcher cross.

At Grand Rapids, in the north-central section, traces of stripe rust were observed on Yuma and Langdon in experimental plots, and 50 percent of the leaves of Khapli were infected.

MINNESOTA AGRICULTURAL EXPERIMENT STATION AND UNITED STATES DEPARTMENT OF AGRICULTURE

STRIPE RUST IN KANSAS IN 1958[3]

S. M. Pady and C. O. Johnston[4]

Summary

Stripe rust, Puccinia glumarum (Schm.) Eriks. & E. Henn., was found on wheat early in May in central Kansas for the second year in the history of the State. The infection centers were well-established, indicating infection during April. By May 26 the rust was present in the western two-thirds of the State. Many fields of susceptible varieties had severities from 50 to 80 percent, and the estimated loss for the State was 1 percent.

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[1]Cooperative investigations, Crops Research Division, Agricultural Research Service, U. S. Dept. of Agriculture, and the Minnesota Agricultural Experiment Station. Paper No. 991, Miscellaneous Journal Series, Minnesota Agricultural Experiment Station.

[2]Pathologist, Crops Research Division, Agricultural Research Service, U. S. Dept. of Agriculture, and Collaborator, Minnesota Agricultural Experiment Station.

[3]Cooperative investigations between Kansas Agricultural Experiment Station and the Crops Research Division, Agricultural Research Service, U. S. Dept. of Agriculture. Contribution No. 524, Serial No. 678, Department of Botany and Plant Pathology, Kansas Agricultural Experiment Station, Manhattan.

[4]Mycologist, Kansas Agricultural Experiment Station, Manhattan, and Pathologist, Crops Research Division, Agricultural Research Service, U.S. Dept. of Agriculture.

Stripe rust (Puccinia glumarum (Schm.) Eriks. & E. Henn.), which appeared in 1957 for the first time in Kansas[5], was found again in 1958 with a wide distribution in the State reaching damaging amounts on susceptible wheat varieties. The first observation of stripe rust was May 12 when it was found in Chase, Marion, Reno, Rice, McPherson, Saline, and Dickinson Counties in central Kansas. In two cases there were well-established centers with indications of at least two rust generations, suggesting that stripe rust had come into the State in April. On May 19 in central and northcentral Kansas stripe rust was found in 20 out of 25 fields in six counties, mostly as traces; in five fields, however, prevalence was 80 to 90 percent. Other observers reported its presence in western Kansas, generally as a trace.

By May 26 stripe rust was general over the western two-thirds of the State. From Topeka to Salina it was present only in trace amounts, while from Salina westward there were heavier infections. Differences were beginning to appear also with respect to varieties, Wichita appearing to be particularly susceptible.

Observations made May 26 and 27 revealed that stripe rust approached 100 percent prevalence on the varieties Wichita, Kiowa, Bison, and Concho, with severities from a trace to 80 percent in the area between U. S. Highways 81 and 83. On other varieties such as Ponca and Cheyenne, the rust occurred usually as a trace. The heaviest stripe-rust infections seemed to be in a band from Saline to Finney counties; that is, in the western half of the State with the exception of the two western tiers of counties where the rust was definitely less prevalent. One field of the Wichita variety in Lincoln County had a severity of 80 percent, and the leaves were beginning to dry.

The most unusual feature of rust epidemiology in 1958 was the general scarcity of leaf rust. Leaf rust was so light that it was not a factor in the loss of the leaves; so, much leaf drying was due to stripe rust alone. This is clearly shown in the photographs (Figs. 1 and 2) taken in western Kansas May 26, 1958. The stripe rust is in long yellow bands with young unbroken sori.

In the irrigated plots at the Garden City Branch Experiment Station on May 26 stripe rust was not particularly abundant, but there was sufficient to obtain the following readings on varietal reaction:

Cheyenne C.I. 8885 : 0
Triumph C.I. 12132 : T
Pawnee x Nebred C.I. 13015 : T+
(Qv-Kr-HF-Pl-Kr) x (Kv-Mqo x Kv-Tm) C.I. 13285 : T+
Rodco : T+
Comanche C.I. 11673 : T
Concho C.I. 12517 : 5
EB-Tm x Oro-Mi-Hp C.I. 12871 : 10
Ponca C.I. 12128 : 10
Bison C.I. 12518 : 20
Kiowa C.I. 12133 : 50
Mi-Hp-Pn X Oro-Ill 1-Cm C.I. 12804 : 50
Wichita C.I. 11952 : 50

At the Fort Hays Branch Experiment Station on May 27 the following information was obtained:

Resistant	Intermediate	Susceptible	Very susceptible
Turkey C.I. 1558	Ponca C.I. 12128	Bison C.I. 12518	Wichita C.I. 11952
Kharkof C.I. 1442	Pawnee C.I. 11669	Kiowa C.I. 12133	
Cheyenne C.I. 8885	Comanche C.I. 11673	Concho C. I. 12517	
Harveyland C. I. 13364 (Iowin)	Triumph C.I. 12132		

With Turkey as a parent, hybrid lines often seemed to have some resistance.

Warm weather in early June caused rapid drying of leaves and checked rust development. On June 12 the field in Lincoln County which had the heaviest infection earlier again was visited; stripe rust had practically disappeared, the foliage was dry, and the grain in the hard-dough stage. A few minute sori were present on the glumes, but they had not broken through the epidermis. In the laboratory it was found that these definitely were stripe-rust pustules. There were no infections on the grain itself. This was the only case where head infection was

[5] Pady, S. M., C. O. Johnston, and C. T. Rogerson. 1957. Stripe rust of wheat in Kansas in 1957. Plant Disease Reptr. 41: 959-961.

FIGURE 1. Five flag leaves showing typical stripe-rust lesions. Taken near Larned, Pawnee County, Kansas, May 26, 1958. There are a few leaf-rust primaries on the two outer leaves.

FIGURE 2. Stripe rust on flag leaves from Hodgeman County, Kansas, May 26, 1958. Leaf rust was not present. In the field from which this was taken stripe rust was 100 percent prevalent with 30 to 40 percent severity.

found. The grain was plump and showed no sign of shriveling despite the desiccation of the leaves by the heavy stripe-rust infection.

In addition to infections on wheat, stripe rust occurred on goatgrass (Aegilops cylindrica) and natural hybrids of goatgrass and wheat growing in the edges of wheat fields or adjacent roadsides. Stripe rust was collected on goatgrass in Lincoln, Ellis, Ness, Lane, Finney, and Hodgeman Counties and on the natural hybrids in Lincoln and Ness Counties. Fields of winter and spring barley growing near stripe rust-infected wheat fields were examined, but no stripe rust was found in them.

According to Climatological Data (Vol. 72, No. 4, 1958) "April was the third consecutive month with below-normal temperatures. April was characterized by cool days with frequent but mostly light falls of precipitation. Over much of the State spring was about 2 to 3 weeks late as the month opened but during the warm weather the first 5 days plant growth was rapid."

It is assumed that stripe rust came into the western half of the State in April. Meteorological data from four stations in western Kansas are given in Table 1 for April and May. In this table an attempt was made to determine the number of infection periods during these 2 months. A favorable period was considered to be one with low temperatures (maximum below 65° F) and some precipitation, since stripe rust is known to develop only under cool, moist conditions. An infection period may extend from one to several days. At Garden City there were seven infection periods in April (Table 1). During May temperatures rose steadily and days of precipitation were fewer; there were three infection periods during the first half and only one during the second.

At Hays (Table 1) the situation was similar, with light rains and numerous cool days. In Colby April was especially favorable for stripe rust development, with 18 days of precipitation, 22 days of low temperatures, and four infection periods, two of which lasted several days. Conditions at Lincoln were favorable in April but were unfavorable in May. It would appear that in western Kansas in 1958 conditions were very favorable for stripe rust in April and the first half of May. Inoculum was provided by heavy infections in the Texas Panhandle in April and May (personal communication from I. M. Atkins, dated May 26). The combination of abundant inoculum in Texas, only 200 miles south, and favorable conditions for rust infection resulted in stripe rust being severe for the first time in the history of Kansas.

An interesting feature of the rust picture in western Kansas was the fact that leaf rust was either absent or only a trace when stripe rust was developing rapidly. On May 26 in southwestern Kansas there were fields with a 30 to 40 percent severity of stripe rust, while leaf rust was difficult to find. This provided an opportunity to assess possible damage from stripe rust uncomplicated by leaf rust. In 1957, on the other hand, the opposite was true, with leaf rust being very severe during the period when stripe rust was developing; as a result, leaf rust caused an estimated 10 percent loss with stripe rust recorded only as a trace. In 1958 the situation was reversed; leaf rust caused an estimated loss of 0.5 percent, with stripe rust 1 percent.

The appearance of stripe rust for the second straight year and for the second time in the history of Kansas raises several questions. In order for infection to occur in Kansas there would seem to be three requirements, a large overwintering source area, an extensive area in Texas and Oklahoma in which a buildup of inoculum occurs in March and April, and finally favorable weather conditions in Kansas. Apparently the rust overwintered in Mexico as in the previous year[6] and moved into the Panhandle of Texas where unusually heavy precipitation provided ideal conditions for another epiphytotic. Favorable conditions in western Kansas in April and the first half of May resulted in widespread infections which approached epidemic proportions in susceptible varieties.

[6]Futrell, Maurice C. 1957. Wheat stripe rust epiphytotic in Texas in 1957. Plant Disease Reptr. 41: 955-957.

Table 1. Meteorological data from four stations in western Kansas where stripe rust was abundant in 1958.

Period	Number of days: Maximum temperature below 65° F	Number of days: With precipitation	Precipitation	Number of infection periods[a]
		Garden City		
April	23	12	1.48	7
May 1-15	5	7	3.62	3
May 16-31	0	4	1.66	1
		Hays		
April	23	9	1.62	4
May 1-15	4	5	3.92	2
May 16-31	0	4	2.86	1
		Colby		
April	22	18	1.59	4
May 1-15	4	7	1.08	2
May 16-31	2	6	1.54	1
		Lincoln		
April	11	9	2.87	6
May 1-15	0	2	.83	0
May 16-31	0	5	1.78	0

[a]Infection periods are periods with maximum temperatures below 65° and with some precipitation, from 1 to 6 days in extent. (From Climatological Data Summary)

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, KANSAS STATE COLLEGE, MANHATTAN, IN COOPERATION WITH THE CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

STRIPE RUST IN WYOMING IN 1958[7]

G. H. Bridgmon and B. J. Kolp[8]

Stripe rust, incited by Puccinia glumarum (Schm.) Eriks. & E. Henn., occurred in abundant proportions throughout southeastern Wyoming in 1958. It was particularly heavy in the high elevation (7200 feet) at the Agronomy Farm in Laramie. At this elevation the infection reached epidemic proportions, as winter wheat is late and spring wheat is particularly late. It was noted generally throughout the four southeastern counties of Wyoming, and by the end of the season some yield damage had occurred. It was estimated that this area had 70 to 80 percent average incidence, and the infection ranged from medium to heavy. It is also estimated that the total gross crop loss from this disease was only 3 to 5 percent because of the maturity of the crop when infected. Severity at Laramie on the Yogo variety was characterized by the infection breaking through the inner surface of the lemma and palea, as well as by heavy leaf-sheath and blade infections. Heaviest infection was noted on the susceptible variety "Onas" in our experimental plots, which agrees with last year's observations. Stem- and leaf-rust losses were negligible in the Wyoming wheat-growing areas, even though some plot readings were moderately high.

Particularly heavy infestations of Puccinia glumarum were noted during September and October on volunteer wheat and on the fall plantings.

Stripe-rust notes on the State and Regional Spring Wheat Nursery are given in Table 1 in comparison with stem-rust severity.

[7]Published with approval of the director, Wyoming Agricultural Experiment Station, as Journal Paper number 119.

[8]Plant Pathologist and Assistant Agronomist, respectively. Wyoming Agricultural Experiment Station.

Table 1. Stripe- and stem-rust severity on wheat varieties in the 1958 State and Regional Spring Wheat Nursery at Laramie, Wyoming.

Variety	C. I. Number	Stripe Rust		Stem Rust	
		Rep. I	Rep. II	Rep. I	Rep. II
		%	%	%	%
Marquis	3641	10	25	25	25
Thatcher	10003	0	0	25	25
Selkirk	13100	0	0	5	25
Lee	12488	0	0	10	10
Mindum	5296	30	40	T	5
Langdon	13165	30	25	T	T
Towner	13247	10	10	0	0
Ramsey	13246	5	T	0	0
Yuma	13245	25	30	0	0
Pilot	11945	T	5	10	15
Onas	6221	100	100	40	25
Cadet	12053	T	5	25	15
Mida	12008	T	5	20	10
Rushmore	12273	0	0	25	30
Centana		25	25	5	5
Reward x C.I. 12632	13406	10	10	T	T
Reward x C.I. 12632	13407	15	25	5	T
Conley	13157	0	T	10	25
K338AA x Ns. 3880.191	13301	35	10	5	10
K338AA x Ns. 3880.191	13302	25	25	5	40
N.D. 4 x Nx3880.227	13317	65	50	10	5
K338AA x Ns 3880.191	13319	50	25	15	T
Rushmore x Kenya Farmer	13320	15	10	0	10
Lee x N.D. 34	13322	10	25	5	T
N.D. 4 x Lee	13324	40	25	T	5
Thatcher x K338AC	13348	30	25	10	T
N.D. 81 x Lee	13349	15	10	5	T
K338AA x N.2350	13350	0	0	20	25
Thatcher x R.L. 2564	13332	0	5	25	15
$Thatcher^6$ x Kenya Farmer	13345	0	0	25	25
Karnvor	13347	10	10	10	25
Overby's	13346	40	40	5	5
II-44-11 x Lee^6	13404	T	0	15	15
Thatcher x Kenya Farmer	13403	T	10	15	5
II-44-29 x Lee	13408	0	T	10	10

WYOMING AGRICULTURAL EXPERIMENT STATION, LARAMIE

SECOND STRIPE RUST EPIPHYTOTIC IN TEXAS HITS WHEAT CROP IN 1958[1]

M. C. Futrell, K. A. Lahr, K. B. Porter, and I. M. Atkins[2]

Epiphytotics of stripe rust, Puccinia glumarum (Schm.) Eriks. & E. Henn., occurred in Texas in 1957 and 1958. Although the disease had previously been observed in the State[3] the first stripe rust epiphytotic in the recorded history of wheat production moved out of Mexico into Texas in the spring of 1957[3]. A number of observers credited the epiphytotic to unusual weather conditions which prevailed in Texas in 1957, when temperatures were below normal and rainfall was heavy. Similar conditions prevailed in 1958. Although these may have been the primary causes of the epiphytotics, other factors seem to have contributed to the stripe rust occurrence during 1957 and 1958.

The acreage of wheat in the Mexican states of Coahuila, Nuevo Leon, and Tamaulipas has been increasing for the past 5 years, and new varieties have been introduced into that area. A sizable acreage of the wheat in the Monterrey area in 1957 and 1958 was seeded to Lerma Rojo, a variety susceptible to stripe rust. The disease occurred in the Monterrey area during both of these years. Stripe rust has occurred in the wheat-producing areas at the higher elevations near Saltillo, Monclova, and Allende in the Mexican state of Coahuila for many years, and was present there in 1958. The increasing number of urediospores being blown out of the Mexican states of Nuevo Leon and Coahuila probably was one of the factors contributing to the buildup of the disease in Texas.

In 1958 stripe rust was first observed at the Beeville station in south Texas on March 3, where it was prevalent in the World Collection of Winter Wheats, especially on varieties introduced from China. These infections were rather light and appeared to be in the second or third generation of development after a spore shower. This would indicate that the initial spore shower that caused infection fell at Beeville sometime in January. Trace infections were observed at Prairie View and Comfort in March. The disease also appeared at College Station during March, and some very susceptible varieties developed heavy infections by late March and early April. Infections were established in all parts of central and north-east Texas from Dallas to Texarkana, as shown in Figure 1, during late March and April. The disease reached epiphytotic proportions on the rolling plains by late April and early May and spread northward through the Texas and Oklahoma Panhandles. Fields in these areas showed 100 percent prevalence and 10- to 70-percent severity. The infection was heavy and uniform over much of the area, as shown in Figure 1. The plants were defoliated in a number of fields. The papery-thin straw commonly described as a symptom of the disease was observed. Straw-breaking and mass-lodging occurred in some fields. The overall damage from the disease was not estimated to be large, since growers harvested a near-record crop; however, test weight was reduced in some areas. Weather that favors stripe rust development likewise is favorable to the wheat plant.

Stripe rust remained active for a long period of time even after temperatures increased in the late spring. The activity of the fungus at warmer temperatures was observed in experimental plots at the Southwestern Great Plains Field Station, Bushland, Texas. This observation would suggest one other possibility as an explanation for epiphytotic occurrence of stripe rust in Texas in 1957 and 1958. A new race of the causal fungus that is adapted to relatively warmer temperatures may have evolved. Should this be the case, the main Wheat Belt of the United States is faced with a new problem.

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[1]Texas Agricultural Experiment Station Technical Article No. 3012. The research work on which this report is based was conducted cooperatively by Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and the Texas Agricultural Experiment Station, College Station, Texas.

[2]Plant Pathologist, United States Department of Agriculture, Agricultural Research Service, Crops Research Division and Texas Agricultural Experiment Station; Assistant Agronomist, Agronomist, Texas Agricultural Experiment Station; and Agronomist, United States Department of Agriculture, Agricultural Research Service, Crops Research Division and Texas Agricultural Experiment Station, College Station, Texas.

[3]Futrell, Maurice C. 1957. Wheat stripe rust epiphytotic in Texas in 1957. Plant Disease Reptr. 41: 955-957.

Table 1. Responses of some hard red winter wheats to stripe rust at Chillicothe, Iowa Park, and Amarillo, Texas, in 1958.

Variety or Hybrid	C.I. or Selection Number	Chillicothe	Iowa Park	Amarillo
Triumph	12132	35MS	20MS	TR
New Triumph	-	5R	-	TR
Rosetta	-	35MS	-	TR
Wichita	11952	70S	55S	50S
Early Blackhull	8856	40MS	10MS	TR
Ea. Blkh.-Tq. x Oro-Med.-Hope	12871	55S	-	50S
Crockett	12702	45MS	30S	50S
Red Chief	12109	15R	5R	0
Blackhull	6251	20MR	20MR	TR
Bison	12518	50S	25S	50S
Tenmarq	6936	45S	25S	60S
Ponca	12128	10R	5R	30MS
Comanche	11673	25MS	15MS	50S
Westar	12110	85S	15S	50S
Pawnee	11669	50S	-	30S
Concho	12517	60S	1tS	50S
Kharkof	1442	5R	5R	50S
Harveyland	-	5R	-	TR
Pawnee x Nebred	13015	20R	-	20R
Blue Jacket x Comanche	13185	55S	-	60S
Blackhull-Oro-Pawnee	13187	90	-	90S
Red Chief x Pawnee	13016	TR	-	TR
Pawnee x (Iowin x *T. timopheevi* x Wis. 5)	13279	50S	-	30S
(Comanche Med.-Hope)Iowin	13188	35MS	-	60S
Quivera hybrid	13285	5R	-	50S
(Kanred-Hd. Fed.-Tenmarq) x Marquillo-Oro [a]	216-49-4	15MR	-	TR
Marquillo-Oro x Wichita [a]	218-53-13	15R	5R	TR
Do.	218-53-15	TR	-	TR
Red Chief-Oro-Turkey-Florence x Marquillo-Oro [a]	240-51-A2	5R	-	TR
Cimarron	12120	10R	-	TR
Kanred-Hard Federation x Mediterranean-Hope	255-48-9	5R	-	10R
Cimarron x (Hope-Cheyenne)	13022	25MR	-	50S
(Kanred-Hard Federation-Tenmarq) x (Med.-Hope) x Cimarron	13023	15R	5R	40MR
(Cimarron-Hope-Cheyenne) x Comanche [a]	13024	TR	5R	TR
La Prevision 25 x Comanche	396-53-39	45S	-	50S

[a]Other selections from these crosses showed good resistance.

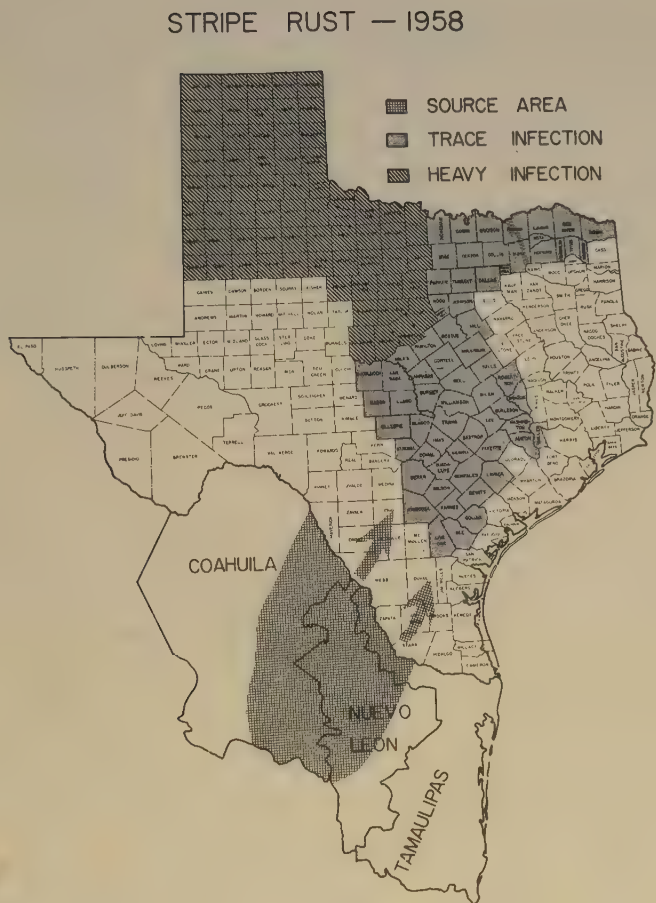

FIGURE 1. Source area of initial inoculum and stripe rust development in Texas in 1958.

Notes on the response of varieties were taken at Chillicothe, Amarillo, and Iowa Park. The responses of common hard red winter wheat varieties and the new breeding strains are given in Table 1. A number of resistant varieties derived from Turkey wheat showed good resistance. The same varieties were resistant in 1957 tests at Amarillo[3].

UNITED STATES DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, CROPS RESEARCH DIVISION, AND TEXAS AGRICULTURAL EXPERIMENT STATION, COLLEGE STATION, TEXAS

STRIPE RUST IN SOUTH DAKOTA IN 1958

Joe F. Hennen and Michael Komanetsky[1]

Yellow stripe rust (Puccinia glumarum (Schm.) Eriks. & E. Henn.) developed throughout the wheat-growing areas of South Dakota during the spring and summer of 1958 (see distribution map, Fig. 1). Previously the only known reports of stripe rust in the State were those on wheat in 1957[2] and one on barley[3] from the Black Hills region.

During 1958 stripe rust was found on winter and spring wheat, winter and spring barley and Hordeum jubatum. The first pustules were found May 27 on winter wheat in the east-central part of the State. Infections were found on May 29 on spring wheat in the northeastern part of the State, indicating that stripe-rust spore showers probably occurred over eastern South Dakota around the middle of May. During the first 2 weeks of June pustules were found on winter wheat throughout the south-central areas of the State, while subsequent surveys indicated its presence over all of the principal wheat-growing areas. Only a trace of severity was recorded for most of the 88 different stripe-rust observations. However, there were seven observations in which the severity was between 5 and 10 percent and one in which the severity was 40 percent. Six fields were observed in which infections occurred within the heads.

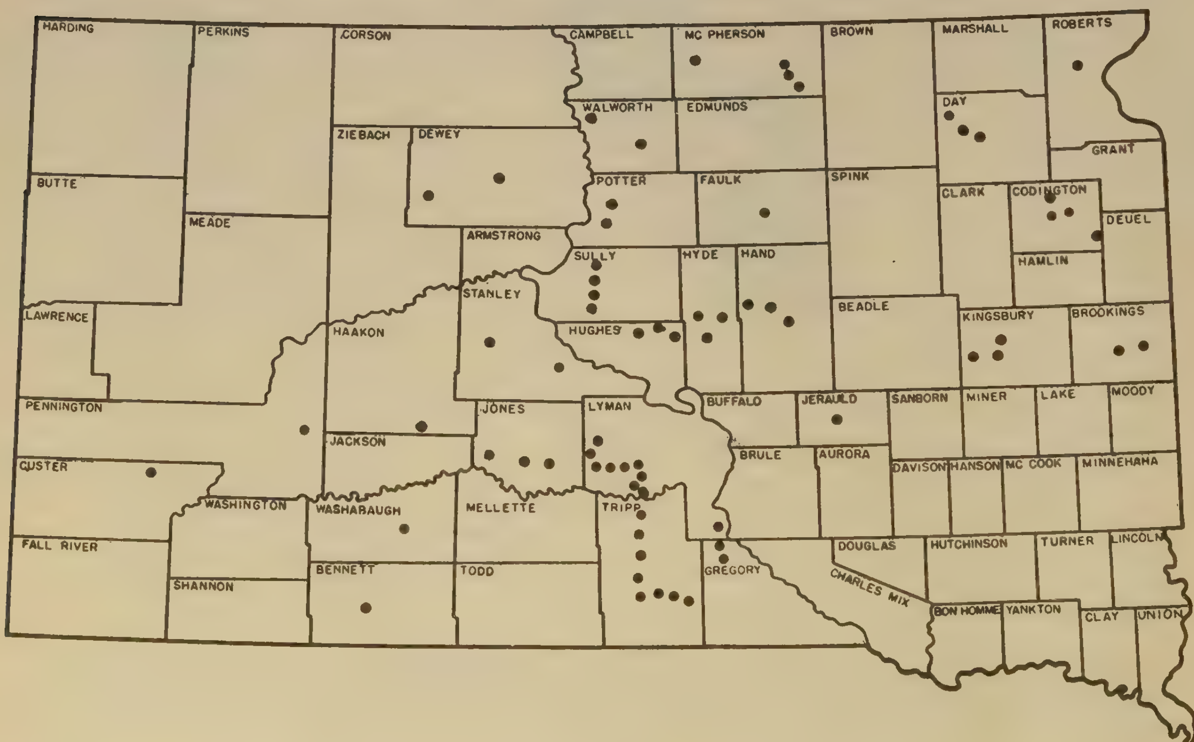

FIGURE 1. Localities of observations of stripe rust in South Dakota during 1958.

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[1] Assistant Plant Pathologist, South Dakota Agricultural Experiment Station, and Plant Pest Control Inspector, Plant Pest Control Branch, Agricultural Research Service, United States Department of Agriculture, respectively.

[2] Hennen, Joe F. 1957. Report for South Dakota in "Short notes concerning stripe rust in other states." Plant Disease Reptr. 41: 962.

[3] Sprague, Roderick, and George W. Fischer. 1952. "Check List of the Diseases of Grasses and Cereals in the Western United States and Alaska." Washington Agricultural Experiment Station Cir. 194.

Table 1. Average weather data[a] from 12 stations in South Dakota during the 1958 stripe rust season.

Week ending	Average temperature	Average departure from normal	Average high	Average low	Average precipitation
July 21	67.2	-8.6	86.4	49.6	0.53
July 14	68.6	-6.4	89.3	51.7	0.66
July 7	69.7	-3.7	93.4	48.2	1.10
June 30	61.0	-4.8	95.1	38.3	0.08
June 23	62.0	-7.0	77.5	45.4	0.40
June 17	58.5	-8.5	82.5	41.7	1.08
June 9	67.0	+2.3	88.8	45.9	0.86
June 3	65.7	+3.4	90.5	41.3	0.51
May 27	62.7	+2.4	85.8	39.3	0.07
May 20	61.7	+3.5	86.5	40.5	0.51
May 13	61.6	+5.4	89.0	33.5	0.21
May 6	49.9	-3.3	79.2	20.2	0.02

[a]From "South Dakota Weekly Weather, Crop and Livestock Reports," issued by United States Department of Agriculture, Agricultural Marketing Service, cooperating with South Dakota Department of Agriculture, Division of Agricultural Statistics.

Average weekly weather conditions prevailing during the current growing season are given in Table 1. It would seem that the warmer than average temperatures in May and the first of June and the cooler than average temperatures during most of June and July were favorable for the development of stripe rust, which is known to be a cool-weather disease.

SOUTH DAKOTA AGRICULTURAL EXPERIMENT STATION, AND AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, BROOKINGS, SOUTH DAKOTA

OCCURRENCE OF STRIPE RUST IN NORTH DAKOTA IN 1958[1]

F. J. Gough, N. D. Williams, and W. E. Brentzel[2]

Stripe rust, Puccinia glumarum (Schm.) Eriks. & E. Henn., was observed in wheat fields in North Dakota in 1958. A brief survey of experiment station records indicated that the occurrence of the disease in North Dakota had not been reported previously. It was found first as scattered traces in experimental nurseries at Fargo on June 15. At that time the pustules were believed to be initial infections of P. rubigo-vera tritici. Rust samples which were collected were identified as P. glumarum by C. O. Johnston, Manhattan, Kansas, and by D. M. Stewart, Cooperative Rust Laboratory, Saint Paul, Minnesota. Stripe rust was observed by E. B. Hayden, Rust Prevention Association, Minneapolis, Minnesota on durum wheat in a field near Valley City, and on several durum varieties in nurseries at Edgeley about July 10. Three weeks later it was observed on durum varieties at Langdon, 20 miles south of the Canadian border. Surveys were not extended beyond these points, but it is doubtful that the rust spread much farther westward since relatively dry weather persisted generally in the central and western areas of the State.

At the northern limits of the survey (Langdon) only scattered traces occurred on susceptible durums, and none were observed on hard red spring varieties. A heavy infection was observed in experimental plots at Fargo, where readings as high as 60 to 70 percent were re-

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Table 1. Stripe-rust reaction of 34 varieties and selections of wheat grown at Fargo, North Dakota, 1958.

Variety or selection	C. I. number	Percent of leaf area destroyed
Mentana		
Selkirk	13100	0
T. timopheevi, D357-1, P,I, 967-1	11651	0
Thatcher	10003	0
N. D. 1 x K338AA, N. D. 121	13512	0
Preston	3081	0
Frontana	12470	0
McMurachy	11876	0
Kenya Farmer	12880	0
Frontana x K58-Frontana, II-50-17	13154	0
Rushmore	12273	0
Lee	12488	0
Conley	13157	0
Thatcher x K338AC, N. D. 4	13000	0
Kenya 338AA x Ns. 3880.191, N. D. 52	13075	t[a]
Bowie	13146	t
Exchange	12635	t
Yuma	13245	5
Ramsey	13246	t
Langdon	13165	50
Golden Ball, R. L. 1250	11477	0
St. 464	13160	0
Khapli	4013	-[b]
Chinese x A. umbellulata, P54-47.4-6	----	0
Marquis	----	-
Reliance	----	0
Kota	----	t
Arnautka	----	5
Mindum	----	40
Spelmar	----	60
Kubanka	----	70
Acme	----	30
Einkorn	----	0
Vernal	----	t

[a]"t" indicates trace severity.
[b]Leaf necrosis caused by Septoria tritici masked stripe rust reaction on Khapli emmer.

corded for certain varieties on July 29. Severity rarely exceeded 5 percent in commercial fields. Entries in the 1958 Spring Wheat Uniform Rust Nursery and 10 of the standard stem-rust differential host varieties, all grown at Fargo, rusted as shown in Table 1. The data are given in terms of percent of the total leaf area destroyed.

The presence of stripe rust in North Dakota resulted from an influx of inoculum from southern States and unusually cool, moist weather conditions. With the exception of one dry and warm period, June 25 to July 2, subnormal temperatures and excessive precipitation prevailed throughout June and July. Measurable amounts of precipitation were recorded for 23 days during the 2-month period. Precipitation in quantities too small to measure or temperatures favorable for dew formation occurred on an additional 30 days. These factors in conjunction with recumbent plant growth provided a nearly continuous cool, humid environment favorable for the development of stripe rust. Weekly temperature and precipitation data recorded for June and July at Fargo by the United States Weather Bureau are given in Table 2.

Table 2. Weekly weather data derived from daily records taken at Fargo, North Dakota for June and July 1958, by the U. S. Weather Bureau.

Week beginning	Temperature (F°) Weekly average and range	Temperature (F°) Departure from normal	Precipitation (inches)[a, b] Weekly total (water equiv.)	Precipitation (inches)[a, b] Departure from normal
June				
1	59.1 (37-80)	-2.4	1.95	Monthly record only, +2.04
8	56.6 (42-73)	-6.8	1.01	
15	59.0 (41-79)	-6.4	0.01	
22	61.4 (43-90)	-5.8	0.44	
29	69.4 (56-87)	+0.1	2.11	
July				
6	63.1 (49-87)	-7.7	0.43	Monthly record only, +3.43
13	66.6 (51-86)	-5.4	1.6	
20	73.0 (53-93)	+1.0	0.68	
27	66.7 (49-86)	-5.3	0.00	

[a]Traces of precipitation in quantities too small to measure occurred on June 1, 7, 21, 29 and on July 1, 6, 11, 14, 15, 24, 27, and 28.
[b]Dew point temperature was higher than the minimum temperature on June 1, 2, 7, 9, 11, 12, 14, 16, 21, 22, 23, 24, 28, 29, 30 and on July 11, 12, 13, 14, 16, 21, 23, 26, and 31.

CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, AND NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION, FARGO, NORTH DAKOTA

SHORT NOTES CONCERNING STRIPE RUST IN OTHER STATES

ARKANSAS

H. R. Rosen

No stripe rust was noted in Arkansas in 1958.

ARKANSAS AGRICULTURAL EXPERIMENT STATION

MISSOURI

M. D. Whitehead

No stripe rust was observed in Missouri in 1958.

MISSOURI AGRICULTURAL EXPERIMENT STATION

IOWA

J. A. Browning

Stripe rust of wheat was not observed in Iowa in 1958. However, observations adequate for establishing the probable presence in or absence from Iowa of stripe rust were not made. Hence it cannot be said with certainty that stripe rust of wheat either did or did not extend its range into Iowa in 1958.

IOWA STATE COLLEGE

NEBRASKA

J. L. Weihing

Stripe rust was noted in trace amounts in Fillmore and Lancaster Counties on May 14 and 15, respectively. The disease was subsequently found throughout the southern portion of Nebraska, except in the panhandle. The region of highest prevalence was Saline and Nuckolls Counties where readings as high as 10 percent prevalence were reported in early June. Following this, leaf rust became very common and stripe rust failed to continue development. No reports of stripe rust were received from the panhandle region. It is not believed that stripe rust caused any loss in yield in Nebraska.

NEBRASKA AGRICULTURAL EXPERIMENT STATION

MANITOBA

G. J. Green

Puccinia glumarum was not observed in Manitoba in 1958, although diligent searches were made for it.

CANADA DEPARTMENT OF AGRICULTURE, SCIENCE SERVICE, PLANT PATHOLOGY LABORATORY, WINNIPEG

WASHINGTON

G. W. Fischer

Stripe rust was negligible, except possibly in isolated instances. It did get a small start early in the year, but the weather has been too warm subsequently for stripe rust.

STATE COLLEGE OF WASHINGTON

AN ACREMONIUM ASSOCIATED WITH STEM RUST PUSTULES

D. S. Pon[1], C. G. Schmitt[2], and C. H. Kingsolver[3]

In June of 1954 Acremonium aranearum Petch[4] was isolated from rust pustules of Race 56 of Puccinia graminis Pers. f. sp. tritici (Eriks. & E. Henn.) from the wheat variety Thorne growing in a field at Frederick, Maryland. A representative single-spore isolation was subcultured on potato-dextrose agar, rice hull agar, lima bean agar, and on oatmeal-dextrose agar. All of the substrates upon which it was grown developed a reddish coloration. Mycelial growth on all media was cottony white as it was on the pustules. Figures 1 and 2 are typical of the appearance of the fungus on the pustules.

Mycelial growth extended into the leaf tissue under and immediately surrounding the rust pustule. Growth of the Acremonium on the pustules was inimical to the Puccinia as evidenced by reduction or termination of sporulation. Actual parasitism of the Puccinia by the Acremonium was not demonstrated.

FIGURE 1. Acremonium aranearum on wheat stem rust pustule.

FIGURE 2. An array of three leaves showing pustules overgrown by A. aranearum.

After inoculation with a spore suspension of A. aranearum, prolongation of the dew periods increased the number of pustules overgrown by the cottony mycelium. Data are in Table 1.

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[1] Now with the Army Chemical Center, Edgewood, Maryland.

[2] U. S. Army Chemical Corps, Fort Detrick, Frederick, Maryland.

[3] Supervisor, Field Crops Unit, Quality Maintenance and Improvement Section, Agricultural Marketing Service, Beltsville, Maryland.

[4] The original isolation of this fungus was made by Petch from a spider in Ceylon in 1931 and reported in British Mycological Society Transactions 16: 242-243. 1931-32.

Table 1. Effect of prolongation of the dew period on the percentage of rust pustules of P. graminis tritici overgrown by Acremonium aranearum.

Dew period at 80°F (hours)	Percent of pustules overgrown
8	31
16	51
24	92
48	98

Non-rusted plants of this variety with needle punctures through the leaves inoculated with a spore suspension of the fungus and held at favorable conditions for its growth were not attacked.

In nature the fungus was observed on only a few pustules in a localized area of a rusted field after an extended period of high humidity.

U. S. ARMY CHEMICAL CORPS, FORT DETRICK, FREDERICK, MARYLAND

THE EFFECT OF PLOWING METHODS AND DATES OF FERTILIZER APPLICATION ON THE INCIDENCE OF FUSARIUM ROOT ROT IN BURT WHEAT[1]

William E. Hall[2]

Summary

Stubble mulch did not increase the disease incidence in Burt wheat from plots plowed with moldboard, disk and sweep plows. Fusarium roseum f. cerealis was present equally on plants from all plots. Classification of disease severity by plant symptom was confirmed by laboratory isolations.

Fertilizer applied at different times during the summer fallow year did not appear to affect the severity of the disease.

Farmers and other agriculturalists have speculated upon the danger of increasing disease losses through the use of stubble mulch fallow. This practice leaves decaying plant material on the soil surface where infection of new plant growth by certain fungi might be more readily accomplished.

Damage due to root rot organisms appears to be increasing in the wheat fields of eastern Oregon and Washington. The "brown root rot" caused by Fusarium roseum f. cerealis (Cke.) emend. Snyd. & Hans. (1) has been the most prevalent problem of this nature in the Columbia basin counties of Oregon and Washington for many years (2, 3). Characteristic symptoms of this disease consist of a dark brown discoloration of the roots and base of the stem. When severe infection occurs the plant ripens prematurely, producing either shrivelled kernels or no kernels.

An existing experiment on plowing methods and fertilizing dates at the Sherman Branch Experiment Station, Moro, Oregon permitted a study of the effect in these treatments on disease incidence.

MATERIALS AND METHODS

The plowing experiment consisted of three plowing methods: moldboard, disk and sweep plowing. Each large plowing plot was subdivided into six fertilizer plots, five of which received thirty pounds of nitrogen per acre at different times during the cropping sequence. The sixth plot received no nitrogen. The experiment was in a randomized block design with three replications.

Fertilizer applications were made at four different times: on the stubble after harvest (10/10/56), in the spring prior to plowing (4/8/57), in the fall at seeding (10/28/57), in the spring of the crop year (4/7/58). A split application was applied at the two latter dates. Burt wheat was seeded on October 18, 1957.

Symptoms of brown root rot were noted on many plants in the spring of 1958. Random plant samples of approximately 100 plants were taken from each sub-plot prior to harvest. The plants were examined for degree of discoloration of the crown and the filling of the kernel in the heads. They were classified as to degree of infection as follows: A -- little or no symptoms, B -- moderate expression of symptoms, and C -- severe symptoms. Isolations made from samples of each disease class yielded F. roseum from B and C, while many of those from class A proved sterile[3].

EXPERIMENTAL RESULTS AND DISCUSSION

Table 1 shows the total plants in each disease classification of the plowing and fertilizing

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[1]Contribution of Oregon Agricultural Experiment Station, Oregon State College, Corvallis, Oregon.
[2]Superintendent of the Sherman Branch Experiment Station. Appreciation is expressed to John Matteson, George Hailey and Phil Gilman, experimental helpers, for many hours of disease classification.
[3]Isolations and identification of the organisms were made by Dr. W. B. Raymer, Assistant Plant Pathologist, Oregon State College.

Table 1. Incidence and severity of brown root rot in Burt wheat as affected by method of plowing and time of fertilizer application at the Sherman Branch Experiment Station, Moro, Oregon in 1958.

Fertilizer applied at:	Method of Plowing												Totals
	Moldboard			Sweep			Disk			Total			
	A[a]	B[b]	C[c]	A	B	C	A	B	C	A	B	C	
Fall (after harvest)	144	129	102	112	207	66	165	151	94	421	487	262	1170
Plowing	117	187	48	127	156	57	165	137	83	409	480	188	1077
Seeding	152	182	33	167	163	42	176	167	49	495	512	124	1131
Spring of crop year	118	198	52	113	125	90	155	164	59	386	487	201	1074
Seeding and spring	171	157	52	170	162	31	153	153	43	494	472	126	1092
No Fertilizer	138	163	41	117	162	60	136	162	58	391	487	159	1037
Totals	840	1016	328	806	975	346	950	934	386	2596	2925	1060	6581
		2184			2127			2270					

[a]A -- little or no discoloration
[b]B -- moderate discoloration
[c]C -- severe discoloration and poorly filled heads

treatments. A total of 6641 plants were classified. There were so nearly the same number of plants in each treatment that it seemed unnecessary to express the classes in percent.

The table shows nearly the same number of plants in each classification from the different plowed plots. The moldboard plowed plots had 840 classed as A. The sweep and disk plots had 806 and 950, respectively. The number of plants in class C from the moldboard, sweep and disk plots were 328, 346 and 386, respectively. This indicates that the disease was present in the same degree in each plowing method.

Fertilizer has often appeared to accentuate the symptoms of root rot. This was not evident when individual plants were classified in this study. The plots receiving no nitrogen had approximately the same number of plants in each classification as did the plots receiving nitrogen. There appeared to be no difference in the severity or incidence of disease from the different dates of fertilizer applications.

Statistical analysis showed no significant interaction of disease severity between date of fertilizer application and plowing method.

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OREGON AGRICULTURAL EXPERIMENT STATION, CORVALLIS

A COMPARISON OF TECHNIQUES AND SITES OF INOCULATION IN FIELD CORN ARTIFICIALLY INOCULATED WITH GIBBERELLA ZEAE (SCHW.) PETCH[1]

R. A. Cappellini

Summary

Methods of inoculating corn with Gibberella zeae (Schw.) Petch by the injection of an inoculum suspension and the insertion of infested toothpicks, pipe cleaners, wheat kernels and agar disks into the stalk tissues were compared. Infested pipe cleaners were found inferior to the other four methods in evaluating stalk rot resistance in a hybrid and an inbred.

When the first four internodes of four inbred lines were inoculated with G. zeae infested toothpicks (one inoculation site per plant), the amount of rot was progressively greater from the first through the fourth internodes in both resistant and susceptible lines.

INTRODUCTION

Efficient inoculation techniques are an important adjunct to the success of a corn breeding program for stalk rot resistance. Moreover, where large scale inoculations and tests of pathogenicity are to be made a technique embodying efficiency and ease of manipulation is desired. Several of the more common methods employed are the injection of an inoculum suspension (3), and the insertion of infested toothpicks (6), pipe cleaners (4), agar disks (5) and wheat kernels (1) into corn stalk internodes.

The site of inoculation on the corn stalk is also important. Hooker (2) found that highly significant differences in extent of rot between susceptible and resistant inbred lines occurred when Diplodia zeae Lév. was inoculated in the first or second elongated internode above ground. No differences in the extent of rot were obtained between susceptible and resistant inbred lines when inoculations were made in the fifth elongated internode. Such a relationship has not been shown with Gibberella zeae (Schw.) Petch.

This paper presents data obtained in comparing five methods of inoculating corn stalks with G. zeae. Also, data is presented on the extent of spread of G. zeae inoculated into different corn stalk internodes of inbred lines differing in resistance to stalk rot.

MATERIALS AND METHODS

An isolate of G. zeae obtained from a diseased corn kernel was used throughout the study. The hybrid N.J. #7 and the inbred Os 420 were used in comparing inoculation techniques. All inoculations were made in the center of the fourth elongated stalk internode. A randomized block design with 10-plant plots and four replications was employed. Quill-type toothpicks were boiled in water, placed in potato-dextrose broth, autoclaved, and infested with G. zeae (6). Pipe cleaners, cut to approximately 2 inches, were infested by thoroughly kneading them into a blenderized suspension of mycelium and spores grown on Difco Potato-Dextrose-Agar. The infested toothpicks and pipe cleaners were inserted into the stalks after puncturing the stalk with a modified ice-pick. Inoculations with infested wheat kernels (1) and agar disks (5) were made by removing a plug of stalk tissue with a 7-mm cork borer, inserting the inoculum and replacing the tissue plug. Approximately 0.5 ml of a mycelial-spore suspension was injected to a depth of 0.5 inch into the stalk using a modified, gravity-flow, hypodermic syringe equipped with a needle 3 mm in diameter.

The relationship of the site of inoculation to the severity of the disease was determined in the inbreds J47, Pa83c and stalk rot resistant and susceptible selections of J48. Stalks were inoculated with infested toothpicks in the center of the first, second, third, and fourth elongated internodes. A single inoculation was made in each stalk. A split-plot design using 10-plant plots and three replications was employed.

All inoculations were made approximately 2 weeks after anthesis. Data were taken 4 to 5 weeks later. Each inoculated plant was cut longitudinally and the length of rotted portion was measured. The data were recorded as the ratio length of rot to length of internode. Individual

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plant data were averaged to obtain a plot ratio. Each experiment was subjected to an analysis of variance.

RESULTS

All of the methods of inoculations compared produced stalk rot in the test plants (Table 1). The least amount of spread of G. zeae occurred with the infested pipe cleaner method. No significant differences were obtained among the other methods.

Table 1. A comparison of five methods used in artificially inducing stalk rot in plants of a hybrid and an inbred field corn line with Gibberella zeae.

Corn line	Average infection ratios[a] from various methods				
	Toothpick	Pipe cleaner	Agar disk	Injector	Wheat kernel
N. J. #7	0.75	0.37	0.68	0.68	0.69
Os 420	0.80	0.32	0.82	0.76	0.85
Average	0.78	0.35	0.75	0.72	0.77

[a] Infection ratio (length of rot/length of internode) is the average of 10 individual plant ratios in four replicates.

L.S.D. .05 = 0.08
.01 = 0.11

Highly significant differences were obtained among inbred lines, between resistant and susceptible lines, and among the four internodes in the four inbred lines inoculated with G. zeae. No interaction between inbreds and site of inoculation was obtained. The least amount of spread of G. zeae occurred in the first inoculated internode and was progressively greater in successive internodes in both resistant and susceptible lines (Table 2).

Table 2. The spread of Gibberella zeae in stalks of four inbred lines artificially inoculated in the first through the fourth elongated internode.

Inbred line	Average infection ratios[a] of the indicated internodes				
	1	2	3	4	Average
J47 (R)[b]	0.28	0.33	0.46	0.60	0.42
J48 (R)	0.32	0.38	0.57	0.64	0.47
J48 (S)	0.42	0.55	0.69	0.79	0.61
Pa83c (S)	0.46	0.67	0.78	0.85	0.69
Average	0.37	0.48	0.62	0.72	

[a] Infection ratio (length of rot/length of internode) is the average of 10 individual plant ratios in three replicates.

[b] (R) = resistant, (S) = susceptible.

DISCUSSION

The choice of a suitable inoculation technique should be limited to one that is quick and produces an optimum degree of infection. The injection method requires the least amount of time for inoculation; the agar disk and wheat kernel methods require the greatest amount of time. Having placed a suitable inoculum suspension in the injector, only one step, the puncturing and simultaneous release of inoculum into the stalk, is necessary. With the other techniques at least two steps are necessary -- preparation of the stalk by either puncturing or tissue removal and, then, placement of the inoculum into the stalk. These differences in amount of time for inoculation become more significant where large numbers of plants are to be inoculated. Where placement of several strains of the test organism (or even several different organisms) into a single inoculation site is important, the injection and pipe cleaner methods are the most suitable. With these two methods an almost unlimited number of isolates can be placed into a single inoculation point. With the toothpick, agar disk, and wheat kernel methods, the number of strains utilized per single inoculation is extremely limited.

When different internodes are inoculated with *G. zeae* in resistant and susceptible corn lines, the pattern of infection varies from that obtained by Hooker (2) in experiments with *D. zeae*. Both resistant and susceptible lines inoculated with *G. zeae* showed progressively more rot from the first to the fourth internode - a type of response shown by Hooker (2) to occur only in the resistant lines inoculated with *D. zeae*. Susceptible lines inoculated with *D. zeae* showed complete susceptibility in all internodes inoculated. Inoculations with *D. zeae*, therefore, should be made in similar basal internodes when comparisons of different corn lines are to be made. The data in the present study show that with *G. zeae* a comparison of lines can be made in any of the first four, similar internodes. Where tests of pathogenicity are to be made it is advisable to make comparisons also from similarly inoculated internodes.

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COMPARATIVE EFFECTS OF CHEMICAL SEED TREATMENT ON THE CONTROL OF TWO HELMINTHOSPORIUM SEEDLING DISEASES OF OATS: LEAF BLOTCH (PYRENOPHORA AVENAE) AND VICTORIA BLIGHT (H. VICTORIAE)[1]

S. S. Ivanoff

Summary

Complete control of Helminthosporium leaf blotch on seedlings was obtained in laboratory experiments by seed treatment with Ceresan M, 1/2 ounce per bushel. Untreated checks produced 65 percent infected seedlings. By the same treatment incidence of Victoria blight was reduced from 99 percent to 12 percent.

H. avenae was found to induce rotting of seedling roots under 100 percent humidity and at 24° to 28° C temperature.

The hazard of leaf blotch is emphasized since no known variety grown in the southern States is resistant to it.

A brief summary of literature on leaf blotch with some personal observations on the two diseases are included.

During the last two seasons weather conditions in Mississippi have been such that grain yields of oats were low at many locations and much seed infection and contamination resulted during the ripening period. Laboratory tests showed that some seed samples contained an unusually high percentage of fungus-infected or contaminated seeds. Two diseases were involved, Victoria blight, caused by Helminthosporium victoriae Meehan & Murphy, and leaf blotch, caused by H. avenae Eidam. This latter disease destroyed many fields of young oats in the fall of the year in 1957 and 1958 by producing spots on the leaves at first, and then killing the plants. In other fields where the oats escaped early destruction the maturing plants showed purpling of leaf sheaths and stems, discoloration, and darkening of the heads. For many years this disease had been considered of minor importance, although some significant outbreaks have been reported (15, 21). Its recent extraordinary development (6, 8, 11, 13) may be explained entirely by unusually favorable weather conditions, but it is also possible that more virulent strains of the fungus have arisen in recent years. A gradual build-up of contaminated seed stocks from year to year may also have contributed to this development. The importance of leaf blotch is further emphasized by the fact that it seems to attack all of the commercial oats grown in the area, including the red "rustproof", Victoria blight-resistant varieties which are grown very extensively, like Nortex 107, Delta Red 88, and others.

After reviewing the early literature on Helminthosporium leaf blotch (2, 4, 5, 7, 18, 20, 22) and adding some personal observations, the following pertinent points may be listed:

1. There are two stages in the development of the disease: (a) the primary, dominated chiefly by the activities of the mycelium; and (b) the secondary stage, initiated and terminated by action of spores. The primary stage begins with infection of the coleoptile from contaminated seed and spreads to the first, second, and third leaves. The second stage follows sometime later with infection of upper leaves, sheaths, and the rest of the plant, including flowers and possibly developing seeds (18), all by means of conidia produced during the primary stage. This stage may be totally destructive, but later infection of flowers and seeds is perhaps equally damaging and, in addition, serves to perpetuate the disease. Darkening of the heads may be caused by other fungi, following H. avenae (9). According to Ravn (20), the attack is most severe "on young seedlings and on the autumn stubbles." Cool, wet periods cause both stages to develop rapidly; warm, dry weather may reduce the secondary stage to a minimum.

2. The symptoms on the first three leaves (primary stage) have been generally described as a few round or elongated spots (lesions) or "stripes." These "stripes" show no reticulation, as in barley net blotch. Their color is described variously as brown, olivaceous, "vaguely gray to grayish brown," reddish brown, purplish-brown, with or without dark or red margins. (This writer's observations confirm the description that the color of the primary lesions is of a purplish-brown shade with a red border in dry weather. The symptoms of the secondary

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[1] Journal paper (New Series) No. 768, Mississippi Agricultural Experiment Station.

stage on various parts of the plant exhibit a definite over-all purple quality. This purple color varies in intensity from very light transparent to powdery blue, or dark purple to almost black, depending on plant part infected or on age of infection.) The dark purple wide stripes on the leaves are conspicuous. The most constant symptom is one or more dark, minute streaks on the coleoptile which appear a few days after the seed begins to germinate.

3. The pathogen is seed-borne. Reports disagree as to whether or not the mycelium is harbored within the pericarp (16, 24). It definitely is found on the inner side of the glumes and paleas. It may remain viable on the seed for 3 years or longer (24). Resting mycelium and conidia seem to be the important factors in pathogenesis. Pycnidia and pycnospores have been described but apparently do not play a part in the epidemics (16, 24). Likewise, perithecia with asci and ascospores found on dead oat stems (3, 10, 24) may be of secondary importance. Differences in pathogenicity of various isolates have been reported (16, 24). Infection of several species of Avenae has been induced (18).

4. The present writer has found that H. avenae causes definite rotting of roots of seedlings under controlled laboratory conditions at moisture-saturated atmosphere and at temperatures of 24° and 28° C (12). The rotting proceeds more slowly than it does in the case of Victoria blight under optimum laboratory conditions. Previous reference has been made to foot and root rots on oats in Minnesota from which species of Fusarium, Alternaria, Brachysporium, and Helminthosporium were isolated (14, 23), but no reports of specific investigations of root infection by this fungus have been found in the literature.

5. Control. In Scotland some years ago (16, 17) good control, but not complete elimination, of the primary stage of the disease was obtained by treatment with Ceresan dust (Improved Tillantin R, containing approximately 3.4 percent metallic mercury) at the rate of 2 ounces per bushel. Degree of control seemed to depend on degree of infestation of seed stock. Certain soak treatments with liquid fungicides gave complete control but were found impractical.

Some specimens with Victoria blight on Victorgrain oat seedlings were received by this laboratory in the fall of 1958 which showed well developed lesions originally described by Atkins (1). These lesions were on the first few leaves. This was the first time the writer had seen these symptoms on field grown seedlings, although they have been observed on much older plants. The lesions may be distinguished from those caused by H. avenae by their tan color and irregular outline, but more definitely by a microscopic examination of the spores which are produced in abundance on the lesions after a short interval of incubation under humid conditions.

TESTS WITH TREATED AND UNTREATED SEED

Because of the great economic importance of leaf blotch in Mississippi and its unusual epidemic development, it was urgent that the extent to which it could be controlled by treating locally grown, naturally infested seed with a dust fungicide be determined. For the sake of comparison, control of Victoria seedling blight by seed treatment was also attempted, even though resistant varieties are now commonly grown. Preliminary experiments were begun in the laboratory with Ceresan M[2], since it is one of the most commonly used dust fungicides. If, under Mississippi conditions, healthy stands could be obtained from diseased or contaminated seed stocks by chemical seed treatment, as had been done elsewhere with similar fungicides, it might help the crop to get established and be used for grazing. Furthermore, the plants may grow for some time before these fungi attack through the atmosphere. It also happens that once a healthy stand has been obtained, and primary inoculum reduced or eliminated, weather may favor further healthy crop development.

In these experiments four lots of seed were used. Lot 1 was Bronco, a Victoria blight-resistant variety, free from this blight but carrying the blotch organism H. avenae to a very high degree, inducing seedling infection to about 66 percent. It was perhaps the most highly naturally infested seed stock ever tested. Lot 2, Victorgrain 48-93, was very badly contaminated with H. victoriae and resulted in a complete crop failure when planted on a commercial scale early in the fall of 1957, as all plants were killed before they were 6 weeks old. Lots 3 and 4 consisted of carefully selected healthy seed stocks of Victorgrain 48-93 and Delair, respectively, and contained no harmful fungi, as far as could be determined in the laboratory. These two lots served as checks in these experiments. Ceresan M was used at the recommended commercial rate of 1/2 ounce to the bushel.

2 Active ingredient: ethyl mercury p-toluene Sulfonanilide 7.7 percent. (Total mercury as metallic 3.2 percent, manufacturer's specifications.)

Table 1. Effect of seed treatment with Ceresan M (1/2 ounce/bushel) on the control, under laboratory conditions, of two seedling blights of oats caused by Helminthosporium avenae and H. victoriae. (Based on four replicated laboratory trials with 2000 seeds from naturally infested and 2000 seeds from healthy stocks).

Kind of seed and pathogen carried	Before treatment with Ceresan M		After treatment with Ceresan M	
	Germination (Percent	Healthy plants obtained (Percent)	Germination (Percent)	Healthy plants obtained (Percent)
1. Bronco with H. avenae	98	34	100	100
2. Victorgrain 48-93 with H. victoriae	92	1	92	87
3. Victorgrain 48-93 free from parasites (check)	93	92	91	90
4. Delair free from parasites (check)	98	97	95	95

The results of these trials, shown in Table 1, and some field observations, may be summarized as follows:

1. In the case of leaf blotch, seed treatment eliminated the disease completely under laboratory conditions most favorable for disease development. Untreated checks produced 66 percent infected plants. In the field the treated seed gave a good healthy stand in small replicated trials, but some disease appeared at about maturity, probably because of contamination from nearby oats. The untreated seed under wet conditions produced rather poor stands, small, unthrifty plants, with the disease becoming evident early, reducing the grain yield in some cases very considerably.

2. In the case of Victoria blight the seed treatment eliminated the fungus to the extent that 88 percent of the seedlings developed without any blight symptoms. This was accomplished under optimum laboratory conditions for the development of this disease. Control under these conditions was evidently not complete since some plants developed the disease in spite of the treatment. Under the same conditions the untreated checks produced 99 percent blighted plants after 2 weeks. In the field untreated seed resulted in complete destruction of the crop at an early age. In previous field tests it had been demonstrated that seed treatment will not prevent Victoria blight from developing later in the season, particularly if the land has been in susceptible oat crop before. As is well known, there are a number of varieties resistant to this disease.

Resistance to leaf blotch may eventually be obtained by breeding. In the meantime, seed treatment (or the use of clean seed), rotation of crops, and keeping away from low, wet land are the best suggestions that can be made to combat this increasingly important disease.

Treating small grains with organic mercury compounds for the control of various seed-borne diseases has been a standard recommendation for many years. No doubt most large commercial seed establishments are following this practice. However, many acres in this region are still sown with untreated seed.

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A NEW RACE OF PHYTOPHTHORA PHASEOLI FROM LIMA BEANS

R. E. Wester and Hans Jorgensen[1]

Between the discovery of downy mildew of lima beans caused by Phytophthora phaseoli Thaxt. by Thaxter in 1889 (1) and 1958 no new races of this fungus had been identified. However, in October 1958 a new race designated race "B" was isolated from pods (Fig. 1) of the U. S. 355 lima bean collected in a 20-acre field at the Newkirk Farm of Seabrook Farms, New Jersey. This line had shown high resistance to the fungus collections used in tests during its development.

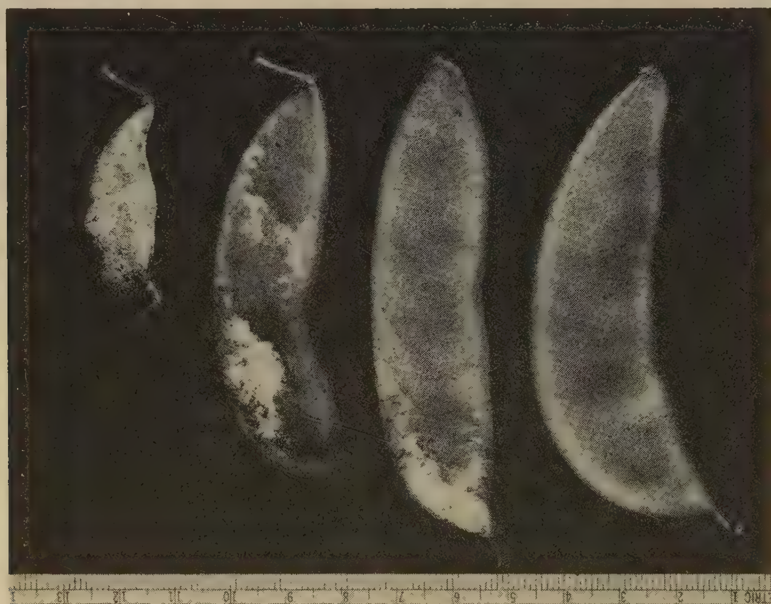

FIGURE 1. Lima bean pods of U. S. 355 lima beans infected with race "B" of downy mildew fungus collected on the Newkirk Farm of Seabrook Farms, New Jersey.

Breeding for downy mildew resistance in lima beans was started by the United States Department of Agriculture in 1948. A race of the causal fungus now called "A", collected in New Jersey, was used to determine susceptibility. Among a collection of 113 lima bean varieties and strains of domestic and foreign origin, only four from widely scattered parts of the world possessed resistance to this race of P. phaseoli (2). These four were used as a basis for breeding downy mildew resistance into commercial bush lima bean varieties.

Every year since the start of the breeding program new collections of the downy mildew fungus were made from commercial lima bean fields in different locations. These were used to inoculate the downy mildew-resistant lima bean lines that were being developed. From 1948 to 1958 collections of the fungus from Long Island and other points in New York, Delaware, Maryland, and New Jersey behaved very similarly and resulted in no active sporulation on resistant lines (Fig. 2).

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FIGURE 2. **Seedlings of** Thaxter (left) and U. S. 355 lima beans (right) showing resistance to race "A" of downy mildew fungus, whereas seedlings of Early Thorogreen lima beans are killed by this race of the fungus.

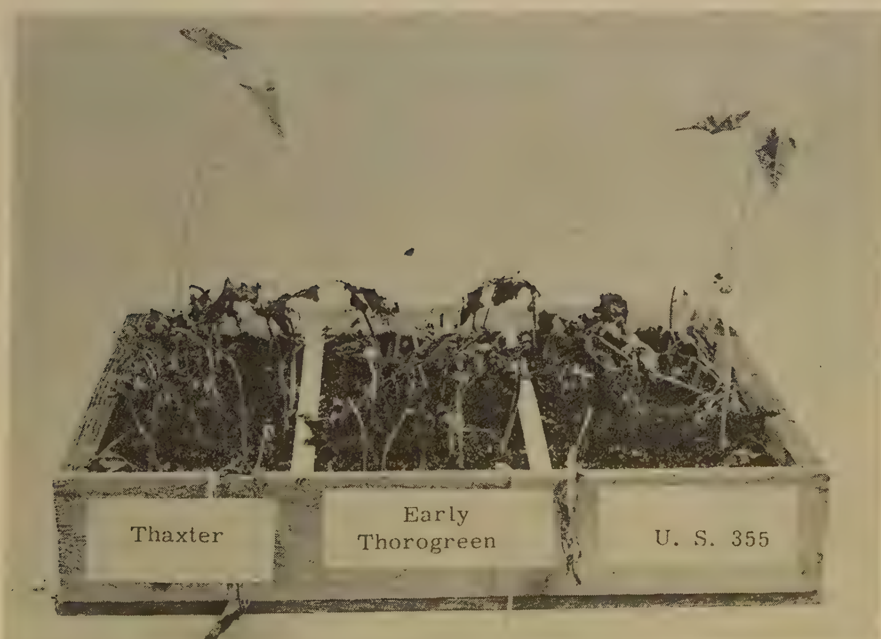

FIGURE 3. **Seedlings of** Thaxter, Early Thorogreen, and U. S. 355 lima beans killed by race "B" of the downy mildew fungus.

In greenhouse tests at Beltsville, Maryland seedlings of Thaxter and U. S. 355 lima beans were found to be very susceptible to race "B", as shown in Figure 3. A sister line of these two lima beans, U. S. 155, as well as the newly developed Fordhook types U. S. 156, U. S. 1556, and U. S. 1656, which were resistant to the race "A", were also found to be susceptible to race "B".

Work is in progress in an attempt to locate resistance to race "B" of downy mildew fungus.

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FUNGI AND ROTS IN CALIFORNIA CANNING TOMATOES

Edward E. Butler[1]

Summary

On the basis of the numbers and kinds of ripe fruit rots, the California canning tomato season is divided into two phases: pre-rainfall and post-rainfall. During the dry period in which humidity is low and rainfall absent, the fruit rots are caused principally by Geotrichum candidum, Rhizopus stolonifer, Mucor hiemalis, and Alternaria tenuis. Although a substantial amount of rot occurs in this period the economy of the crop is not threatened. This is not the case in the post-rainfall period where fruit rots are prevalent and losses heavy.

Species of fungi associated with ripe fruit rot during the post-rainfall period were determined from isolations made in 1956 and 1957. Alternaria tenuis was the fungus most frequently isolated in both years; it occurred in 65 percent of the fruit sampled in 1956 and 51 percent in 1957. Although 13 species of filamentous fungi were identified from rotted fruit, four species accounted for 91 percent of all isolations in 1956 and 80 percent in 1957. These were A. tenuis, Stemphylium botryosum, Geotrichum candidum, and Botrytis cinerea.

INTRODUCTION

The complex of ripe fruit rots occurring in the California canning tomato crop is quite different from that in other important tomato-growing areas of the United States. Highly infectious primary parasitic fungi which attack fruit, such as Alternaria solani (Ell. and G. Martin) Sor. and Colletotrichum phomoides (Sacc.) Chester, are not present or are rare in the canning fruit areas.

Processors and tomato growers refer to rotted fruit as "mold" and such terms as "black mold" and "water mold" are part of the vernacular of workers in the tomato industry. But the precise cause and nature of fruit rots in the California canning crop are unknown or the data are unpublished. Thus, as part of a long-range program on the control of fruit rots, critical determinations were made of the fungus flora of ripe rotted fruit. In certain cases where the information seemed of value, the pathogenicity of selected species was tested. This actually involved very few species, for the pathogenicity of many of the fungi is well known. The frequency of occurrence and location of fungi within the fruit tissue were determined. The latter seemed to be related to the general aggressiveness of the individual species and to the mode of entry into the fruit. In addition, seasonal distribution and general symptoms of fruit rots are discussed. In some cases where clarification seems important, comments are made on the taxonomy of the fungi.

METHODS AND MATERIALS

Isolations were made from rotted tomato fruit during the period October 9, 1956 to October 29, 1956 and October 9, 1957 to November 15, 1957; these were peak periods for numbers of rotted fruit. In 1956 fruits were obtained from lots enroute to canneries in Yolo and Sacramento counties and from a field at Davis. In 1957 fruits were collected from fields in San Joaquin, Stanislaus, Yolo, and Sacramento counties. Most of the fruits in both years were of the Pearson or Ace variety. No particular attention was given to the type of defect selected for study. However, the majority of the fruits had surface spots of various types. Fruits were dipped for 1 minute in a 1-2000 solution of dimethyl di-dodecenyl ammonium chloride to eliminate surface contamination. Fruits were then cut with a sterile knife from the side of the fruit opposite a lesion in such a way as to cut through the center of the underside of the lesion. Samples of tissue were then taken at estimated depths of 8, 16, 24, and 32 mm on a straight line under the center of the spot. The first sample was generally taken from the inner edge of

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Table 1. Relative frequency of occurrence of fungi in ripe tomato fruits and the mean depth from the center of lesions at which each species was isolated.

Fungi	Number of fruits from which each species was isolated: 1956	1957	Mean depth of isolation (mm)[a]: 1956	1957
Alternaria tenuis sensu Neergaard (=Alternaria fasciculata (Cke. and Ell.) Jones and Grout)	175	110	15	18
Stemphylium botryosum Wallr.	65	27	16	18
Stemphylium consortiale (Thuem.) Groves and Skolko (=S. ilicis Tengw.)	10	0	-	-
Unidentified yeasts	43	30	28	23
Geotrichum candidum Lk. ex Persoon emend Carmichael (4) (=Oospora lactis (Fres.) Sacc.)	38	24	23	19
Cladosporium herbarum Lk. ex Fr. (sensu Bisby (2))	16	6	20	13
Verticillium albo-atrum Reinke and Berth.	16	2	25	20
Fusarium oxysporum Schlecht.[b]	15	5	24	18
Fusarium roseum (Lk. ex Fr.) emend Snyder and Hansen[b]	5	4	-	-
Fusarium sp.	1	0	-	-
Mucor hiemalis Wehmer[b]	14	9	21	17
Mucor spp.	0	6	-	-
Botrytis cinerea Pers. ex Fr.	13	37	18	26
Rhizopus stolonifer (Ehr. ex Fr.) Vuillemin (=Rhizopus nigricans Ehr.)	12	1	-	-
Unidentified sterile fungi	8	1	-	-
Rhizoctonia solani Kuehn	6	5	-	-
Pullularia pullulans (d. By.) Berkhout	6	2	-	-
Penicillium spp.	2	2	-	-
Aspergillus spp.	2	0	-	-

[a]The depth at which each species was obtained in fruit tissue is recorded only for the most frequently occurring species.

[b]The author is indebted to Dr. H. N. Hansen for identifying representative cultures of F. oxysporum and F. roseum and to Dr. C. W. Hesseltine for confirming the identification of Mucor hiemalis. The author is also grateful to Betsy Pine and Dolliver Zaiger for technical assistance and to Margery Mann for the photographs.

the fruit wall. The mean depth in the fruit at which each species was isolated was computed for the fungi associated with definite lesions. Isolations were made from 271 fruits in 1956 and 220 in 1957, giving a total of 1964 platings of fruit tissue. Tissue samples were placed on acid potato-dextrose agar and potato-dextrose agar containing the antibiotic novobiocin (3).

RESULTS AND DISCUSSION

The fungi isolated from defective fruits and the mean distance from the surface toward the inside of the fruit at which each species was isolated are given in Table 1. It is doubtful that the frequencies of occurrence of some of the species reflect their actual numbers in nature. Nevertheless, essentially the same species occurred in both years and each species is no doubt important in the over-all rot picture.

Alternaria tenuis was clearly the most prevalent species; in 1956 it occurred in 65 percent of the fruits sampled and in 1957, 51 percent. It would seem likely to be the mold most frequently encountered in processed tomato products in California. Like most of the fungi listed in Table 1, A. tenuis is an ubiquitous secondary facultative parasite. It is first encountered in obvious quantity in California tomato fields on fruits damaged by exposure to intense sunlight. The sun-damaged surface areas of ripe fruit are whitish to yellow to orange in color, depending on the stage of maturity at which fruits were excessively exposed. Symptoms on each fruit affected with A. tenuis are minute brown to black flecks (Fig. 1, left) and small depressed dark spots (Fig. 1, center) which enlarge and coalesce to form a large heavy-sporulating area on the surface of the fruit (Fig. 1, right). The amount of sun damage and, thus, of A. tenuis increases during the season, particularly in fields affected with Verticillium wilt or other conditions which lead to defoliation. Thus the tomato crop, per se, is responsible for the production of great quantities of air-borne inoculum relatively early in the season. The presence of vast numbers of conidia in tomato fields at the time of the first harvest no doubt accounts for the high incidence of A. tenuis in rotted fruits throughout the harvest season as injuries occur to the fruits during picking.

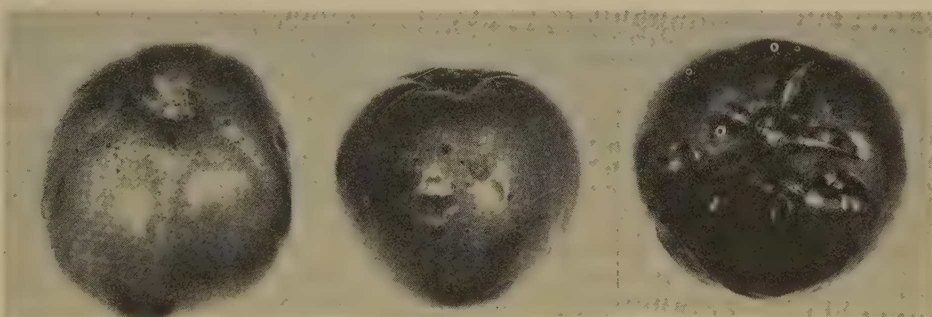

FIGURE 1. Symptoms of Alternaria tenuis on ripe tomato fruit following sun damage.

The taxonomy of Alternaria tenuis is complex. The history of the name and a discussion of the taxonomic problems involving this species have been given by Wiltshire (25) and Neergaard (15). Wiltshire stated that, according to the rules, A. tenuis Nees is invalid. He therefore suggested that A. tenuis Auct. be used in the citation for the group of Alternaria forms mentioned in the literature as Alternaria tenuis. In the present paper A. tenuis sensu Neergaard has been used. Although this citation is also invalid it leaves no doubt as to the identity of the fungi involved. A survey of the early literature, especially of Fries (5), leads only to the conclusion that if the present rules are followed Alternaria tenuis will probably never be the valid name. Alternaria fasciculata (Cke. and Ell.) Jones and Grout is possibly the earliest known combination of the species in question.

In order to establish that A. tenuis is capable of causing rot in ripe fruits, more than 200 ripe fruits of the Pearson variety were inoculated with spores from two isolates of A. tenuis and incubated at 20° C and 80 percent relative humidity. Inoculations were made with a needle 1 mm in length previously dipped into a spore suspension. In most cases the organism grew into the surrounding tissue and produced a more or less sunken firm lesion with a dark center. At 7 days the mean diameter lesion was 18 mm. These results demonstrate that A. tenuis is a parasite of ripe fruit.

According to McColloch (13), the literature on Alternaria rot of tomatoes caused by A. tenuis is not extensive and publications on tomato diseases from California (11, 18) and other areas (1, 10, 19, 20, 21, 23, 26) do not mention this fungus. This would suggest that either

A. tenuis is not of economic importance or more likely that in other areas major attention has been given to highly virulent pathogens which, if neglected, might result in a complete crop failure. In any case, the situation is different in the canning crop of the central valley of California where in most years A. tenuis is the most prevalent pathogen of ripe tomato fruit and is often responsible for large losses.

Stemphylium botryosum was obtained from tomato fruit in both years (Table 1). On V-8 juice agar (14) cultures are brown to black, zonate and produce abundant perithecia. On pea straw agar sterilized with propylene oxide (9) and on V-8 juice agar, perithecia were infertile after 40 days at 20° to 25° C. However, after 4 to 6 months on V-8 juice agar at 3° to 6° C, a sufficient number of perithecia were fertile to identify the cultures as Pleospora herbarum (Pers.) Rabenh. Ramsey in 1935 (17) reported Pleospora lycopersici El. & Em. Marchal as occurring on tomato fruit from California shipped to eastern markets. Since that time the Pleospora on California tomato fruit has been referred to in pathological literature as P. lycopersici. Neergaard (15) is of the opinion that P. lycopersici is a synonym of P. herbarum and the illustrations and descriptions of the perithecia, asci, and ascospores given by Ramsey (17) for the California isolates of P. lycopersici fit the description of P. herbarum given by Wehmeyer (24). Thus it appears that the Pleospora species obtained from California tomatoes are rightly referred to as Pleospora herbarum (=S. botryosum). Critical studies are now in progress on the ecology, taxonomy, and pathogenicity of Stemphylium and Pleospora species obtained from tomatoes in California.

Stemphylium botryosum is a facultative parasite with a wide geographical distribution. It has been isolated from tomatoes in Florida (8) and California (16), and no doubt appears in all tomato-growing areas of the United States. Neergaard considers it to be a weak parasite with rather slight economic significance. In California, at least one form is a primary parasite of lettuce and it is of more than slight economic significance on tomatoes. In 1956 approximately 11.0 percent of the rotted fruits from which isolations were made yielded S. botryosum. In the field S. botryosum is associated with depressed brown to black lesions which develop into large black sporulating areas on the fruit and with watery spots which appear on the fruit following a rain. Symptoms of fruit infected with this fungus cannot readily be distinguished from symptoms caused by A. tenuis.

Seven isolates of S. botryosum were inoculated into ripe and green fruits of the Pearson variety in the field in 1958 by the same technique previously mentioned for A. tenuis. After 12 days brown to black lesions 2 to 3 cm in diameter formed on the ripe fruit. Green fruits were immune. Similar results were obtained in the laboratory. Ripe fruits were inoculated as in the field and placed in polyethylene bags. After 5 days at 23° C brown lesions 1 to 2 cm in diameter appeared on each of the seven replicates of each isolate.

Stemphylium consortiale is reported for the first time from tomato fruit. It appears not to be as prevalent as S. botryosum. In culture on PDA or V-8 juice agar it sporulates heavily forming black grape-like clusters of spores (7). S. consortiale is no doubt common in California. The author has isolated it a number of times from cultivated soils in the Sacramento Valley. Two isolates were tested for pathogenicity in the field and in the laboratory using methods as for S. botryosum. S. consortiale was nonpathogenic in the field and in laboratory tests it produced brown lesions less than 1 cm in diameter at the point of inoculation. At best it would be considered a very weak pathogen.

Mucor hiemalis is a highly virulent pathogen. On ripe fruits inoculated in the manner used for A. tenuis, watery lesions with a mean diameter of 4.0 cm developed on the fruits after 5 days at 25° C.

Seasonal Occurrence of Rot and General Symptoms

Most of the canning tomatoes are grown in the central valley of California in the counties previously mentioned. The crop is grown entirely under irrigation and the majority of the fruit is harvested between August 15 and October 30.

On the basis of the number and kinds of ripe fruit rots the growing season may be divided into two phases: pre-rainfall and post-rainfall. During the rain-free period (August 1 until approximately September 15) the most common fruit rots are Geotrichum rot, Rhizopus rot, Mucor rot, and Alternaria rot. Substantial losses are sustained during the dry season but these have not been a threat to the economy of the crop. This is not the case in the post-rainfall period where serious damage occurs following rains in late September and October. Large numbers of rotted fruits appear 48 to 72 hours following a rain if moisture persists and if wet conditions continue for a week or more the crop will be entirely lost.

In the post-rainfall period the rots are characterized by two main symptoms on the fruit: 1) brown to black circular spots of varying size, and 2) discrete water-soaked circular lesions clearly delimited from firm healthy tissue. Water-soaked spots are prevalent 48 to 72 hours following a rain. Growers refer to these lesions as "water mold," but they are not caused by any of the fungi of the order Peronosporales. Isolations from water-soaked spots and brown to black lesions yielded essentially the same fungi. A. tenuis was the fungus most commonly isolated from all types of lesions during October of 1956 and 1957.

Entrance of Pathogens into Fruit

Mechanical injuries to fruits during harvest and natural growth cracks in the fruit wall provide important avenues of entrance of rot fungi, especially during the dry part of the season. But the sudden appearance of discrete lesions on the fruit following a rain raises the question: How do weakly parasitic fungi such as A. tenuis enter the fruit? No sign of entry by way of wounds is visible. Warner (22), who undoubtedly worked with A. tenuis, stated that the most efficient mode of entry was through wounds but that rotted fruit resulted if young flower stigmas were brushed with spores. The location of A. tenuis in various fruits (Table 1) clearly shows that, in most cases, the fungus is near the surface; it did not originate in the center of the fruit. In addition, lesions are scattered at random over the fruit surface. The more or less sudden appearance of secondary pathogens inside of apparently uninjured ripe fruits following a moist period remains unsolved. Possibly the mycelium of fungi such as Alternaria tenuis and Stemphylium botryosum remains dormant in fruit tissues until ripening and subsequent predisposition of the fruit by environmental factors allow for expression of rot. However, it seems more likely that the fungi gain entrance through microscopic growth cracks formed by excessive water absorption during rainy periods.

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TOMATO FUNGICIDE TESTING ON THE WEST COAST OF FLORIDA[1]

Grover Sowell, Jr. [2]

Summary

Maneb, nabam + $MnSO_4$, and zineb were equal in disease control and effect on yield and quality of tomatoes grown in the west coast area of Florida. Use of nabam + $ZnSO_4$, which was equal to the other carbamates in disease control, consistently resulted in lower yields. 2,4-Dichloro-6- (o-chloroanilino) -S- triazine at 2 pounds 50 percent wettable powder (Dyrene) per 100 gallons was superior to the above carbamates in the control of gray leaf spot, caused by *Stemphylium solani* Weber. A basic copper sulfate fungicide (Tennessee Tribasic Copper Sulfate) at 4 pounds per 100 gallons + 100 ppm streptomycin (Agristrep) gave better control of bacterial spot, caused by *Xanthomonas vesicatoria* (Doidge) Dows., than did either streptomycin at 200 ppm or basic copper sulfate alone. Calcium chloride at 4 pounds per 100 gallons, as used for blossom-end rot control, is compatible with nabam + $MnSO_4$, nabam + $ZnSO_4$, zineb, Dyrene, DDT, and parathion.

LITERATURE REVIEW

No attempt is made to review completely the literature on tomato fungicide testing in Florida. A few of the more important contributions that have formed the basis of the present investigation are mentioned below. Borders (1) found that the carbamate fungicide nabam + $ZnSO_4$ was superior to neutral copper fungicides or to Bordeaux mixture for the control of late blight, caused by *Phytophthora infestans* (Mont.) d By., of tomatoes grown in the Dade County, Florida area. These results were confirmed in the west coast area of Florida by Harrison (10). In addition to providing good control of late blight, the carbamates also control gray leaf spot, which may cause losses equal to those caused by late blight.

Conover (5) tested all of the carbamate fungicides currently used on tomatoes to control late blight. He found that the use of nabam + $MnSO_4$, maneb, zineb, or nabam + $ZnSO_4$ resulted in good disease control. Nabam + $ZnSO_4$, while not causing a statistically significant yield reduction in any one season, caused a significant reduction when the data from several seasons were analyzed together. Plants sprayed with nabam + $ZnSO_4$ showed symptoms of phytotoxicity on the foliage and fruit. Recently Conover (7) and Sowell (12) have found that 2,4-Dichloro-6- (o-chloroanilino) -S-triazine (Dyrene) is superior to the carbamates in the control of gray leaf spot. Many Florida growers are currently using $CaCl_2$ to control blossom-end-rot; this practice is based on the work of Geraldson (9). Although this salt has been used by growers for several seasons without any observable deleterious effects, no data on its compatibility with fungicides and insecticides have been available.

Bacterial spot, a third major tomato disease in Florida, is not controlled by the carbamates. Weber and Ramsey (14) obtained good control with Bordeaux mixture and with copper-lime dust. Conover (3) found that streptomycin gave excellent control of the disease whereas none of the fungicides tested, including those containing copper, controlled the disease under the severe disease conditions of his test. In contrast, Walter (13) reported that although the copper fungicides varied in their effectiveness, two of them, Yellow Cuprocide and Cop-O-Zinc, controlled bacterial spot in the seedbed. He also reported that streptomycin was highly effective.

Later Coe (2) and Conover (4, 6) demonstrated that streptomycin and streptomycin + Terramycin sprays are also effective in controlling the disease when used on tomatoes after they are transplanted to the field. An additive effect of copper fungicides and streptomycin in the control of bacterial spot has been reported by Cox (8).

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[1] The author wishes to acknowledge the criticisms and suggestions offered by Dr. A. F. Ross, Dr. Charles Chupp, Dr. A. G. Newhall, and Dr. E. L. Spencer.

[2] Formerly Assistant Plant Pathologist, Gulf Coast Experiment Station, Bradenton, Florida. Present address: Department of Plant Pathology, Cornell University, Ithaca, New York.

MATERIALS AND METHODS[3]

A high-clearance sprayer similar to those used by local growers was used to apply the fungicides in tests made in the fall of 1955 and the spring of 1956 and for the first four applications of the 1956 fall tests. For the remaining applications of the 1956 fall tests and the 1957 spring tests, a "John Bean" portable pumping unit, mounted on a tractor-drawn trailer, was used. From two to eight nozzles delivering 50 to 200 gallons per acre and a pressure of 300 to 400 pounds / square inch at the pump were used for most applications. A Champion knapsack sprayer was used to make two of the applications early in the 1957 spring season test when it was too wet to use a tractor. The knapsack sprayer was used to apply fungicides to all of the plants while they were in seedbeds or flats. The plants used in all of the replicated field tests, except those used in the 1955 fall test, were sprayed with zineb, maneb, or an alternating schedule of these fungicides before the plants were set in the field. In the 1955 fall test, however, two replications were set with plants sprayed in the seedbed with basic copper sulfate alternated with zineb, and two replications were set with plants sprayed with basic copper sulfate + streptomycin alternated with zineb. These two seedbed schedules had no statistically detectable effects on the disease control or yield. The coined and/or chemical names and the name and amount of trade materials used per 100 gallons of water in the replicated field tests were as follows: nabam + $ZnSO_4$, 2 quarts Dithane D-14 (19 percent disodium ethylene bis [dithiocarbamate]) + 0.75 pound 36 percent $ZnSO_4$; nabam + $MnSO_4$, 2 quarts Dithane D-14 + 1 pound Techmangam (75 percent $MnSO_4$); nabam + $ZnSO_4$ + $CuSO_4$, 2 quarts Dithane D-14 + 0.6 pound 36 percent $ZnSO_4$ + 0.25 pound 25 percent $CuSO_4$; nabam + $ZnSO_4$ + basic copper sulfate, 2 quarts Dithane D-14 + 0.5 pound 36 percent $ZnSO_4$ + 1 pound Tennessee Tribasic Copper Sulfate (53 percent metallic copper); maneb, 1.5 pounds Dithane M-22 (70 percent manganous ethylene bis [dithiocarbamate]) in fall 1955 test, 1.5 pounds Manzate (70 percent) in other tests; zineb, 2 pounds Dithane Z-78 (65 percent zinc ethylene bis [dithiocarbamate]); basic copper sulfate, 4 pounds Tennessee Tribasic Copper Sulfate 2,4-dichloro-6- (o-chloroanilino) -S- triazine, 2 pounds Dyrene. The number of applications and amount per 100 gallons of water are listed in Tables 1 and 2, unless otherwise stated.

The variety Jefferson was used in the 1956 tests, and Homestead-24 was used in the 1955 and 1957 tests. The design of the replicated field tests was a split plot with four replications. Half of each fungicide plot was sprayed with separate applications of the following materials: 1955 fall test, 16 applications of streptomycin at 200 ppm as separate applications; 1956 fall test, two applications of $CaCl_2$ at 4 pounds per 100 gallons added to fungicides; 1957 spring test, seven applications of $CaCl_2$, applied as above. Parathion (1 pound 15 percent wettable per 100 gallons) and DDT (2 pounds 50 percent wettable per 100 gallons) were added to the fungicides or applied alone on the check plots as needed for insect control. Yield data are expressed as total yield of marketable fruit. In the 1956 spring test yield data were not taken because the plants were severely damaged by a drought.

In addition to the replicated field tests which were conducted on the grounds of the Gulf Coast Experiment Station, three cooperative tests were conducted on the farms of growers. In the cooperative tests, the grower's sprayer operator applied each of the test materials to two blocks that were 10 rows wide and extended the length of the field. In the 1955 fall test, three streptomycin-containing treatments were compared with basic copper sulfate, the standard material for control of bacterial spot. The 1956 fall and 1957 spring cooperative tests were designed to compare a straight schedule of Dyrene with the alternating schedule of zineb and maneb used by the grower on the remainder of his crop.

Incidence of gray leaf spot was evaluated by collecting the youngest fully expanded leaf from each of 10 plants selected at random from each plot and counting the number of lesions on them (1956 spring replicated test and 1956 fall cooperative test) or by rating each plot on a scale from 1 to 5, depending on disease severity (1956 fall replicated test).

In the 1956 fall seedbed test on bacterial spot control, reported in Table 2, the plants were grown in flats exposed to natural weather conditions. Three flats each of tomato (varieties Jefferson and Manalucie) and pepper (variety California Wonder) were sprayed at 3- to 6-day intervals with each treatment. Seven such applications were made with a Champion knapsack sprayer. These seedlings were inoculated with a suspension of _X. vesicatoria_ prepared by culturing the organism on potato-dextrose agar. This same procedure was used in inoculating the plants in the 1955 fall field test.

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[3]All of the fungicides and antibiotics were supplied without cost by the manufacturers.

Table 1. Yield of marketable fruit and incidence of gray leaf spot in tomato fungicide trials.

Treatment	Amount per 100 gallons[a]	1955 Fall test Yield[b]	1956 Spring test Gray leaf spot lesions[c]	1956 Fall test Yield	Gray leaf-spot Rating[d]	1957 Spring test Yield[e]
Nabam + $ZnSO_4$	2 quarts + 0.75 pounds	756	502	217	9	273
Nabam + $MnSO_4$	2 quarts + 1 pound	862	1360	305	8	400
Maneb	1 pound	903	700	243	11	
Zineb	2 pounds	922		277	9	385
Nabam + $ZnSO_4$ $CuSO_4$	2 quarts + 0.6 pound + 0.25 pound		622			
Nabam + $ZnSO_4$ + Basic copper sulfate	2 quarts + 0.5 pound 1 pound		920			
Dyrene[f]	2 pounds		388	251	4	340
Basic copper sulfate	4 pounds	574				
No Fungicide			2951	161	15	60
LSD .05		219	897	150	0.8	123
LSD .01			1234		1.17	173

[a]The amounts listed here refer to the trade materials.
[b]Sixteen applications were made. Yield is expressed as pounds of marketable fruits per four replications (1/109 acre in Fall 1955 test, 1/244 acre in other tests).
[c]Nine applications were made. Data listed in this column represent the number of lesions on 40 leaves selected at random.
[d]Twelve applications were made. Incidence of gray leaf spot rated 1-4. Data in this column represent the sum of the ratings for four replications.
[e]Seventeen applications were made. A single application of nabam + $MnSO_4$ was applied to these plants when late blight became severe.
[f]Fifty percent 2,4-Dichloro-6-(o-chloroanilino) - S - triazine.

RESULTS

Nabam + $ZnSO_4$ was consistently inferior to the other carbamate fungicides tested with respect to the weight of marketable fruit produced (Table 1). In the 1955 fall test and in the 1956 fall test this depression of yield was not statistically significant. In the 1957 spring test, however, the differences in yield between nabam + $ZnSO_4$ and nabam + $MnSO_4$ was statistically significant at the 5 percent level. Dyrene gave the best control of gray leaf spot during the two crop seasons when it was tested in replicated experiments. In the 1956 fall test, Dyrene was superior to all other fungicides in the control of gray leaf spot (statistically significant at the 1 percent level). The use of $CaCl_2$ mixed with the fungicides and insecticides had no effect on yield, on disease or insect control, or on appearance of the plants.

In the 1956 fall cooperative tests with local growers, 57 lesions were counted on the 20 leaves selected from the Dyrene-treated plants whereas there were 400 lesions on the leaves sprayed with an alternating schedule of zineb and maneb. Counts made later in the season

Table 2. Number of seedlings, of 10 selected at random from three flats each of tomato and pepper, free of bacterial spot.

Treatment	Amount[a] per 100 gallons	Healthy seedlings[b] Pepper	Tomato	Total
1. Basic copper sulfate	4 pounds	6/30	0/30	6/60
2. Calcium copper chloride	4 pounds	1/30	1/30	2/60
3. Basic copper sulfate plus streptomycin	4 pounds 100 ppm	26/30	24/30	50/60
4. Streptomycin	200 ppm	26/30	2/30	28/60
5. Basic copper sulfate plus streptomycin	4 pounds 400 ppm			
6. For first two applications Basic copper sulfate plus streptomycin For remaining applications	4 pounds 100 ppm	28/30	20/30	48/60
7. Streptomycin	100 ppm	13/30	1/30	14/60
8. Streptomycin plus glycerol	100 ppm 8 pounds	21/30	10/30	31/60
9. None		0/30	0/30	0/60
LSD .05				11/60
LSD .01				16/60

[a]The amounts listed refer to the commercial formulation used, that is, for basic copper sulfate, Tennessee Tribasic Copper Sulfate; for calcium copper chloride, Copper A Compound; for streptomycin, Agristrep (Treatments 3-6) or Streptomycin STS Merck (Treatments 7 and 8).
[b]Numerator = number of healthy plants. Denominator = number of plants examined.

were 456 and 1965 lesions, respectively. Late blight was not severe enough to permit an evaluation of the control of this disease except in the 1957 spring crop season, when the Dyrene-sprayed plants were severely affected in the replicated trials and in the cooperative grower tests.

Basic copper sulfate used throughout the crop season was tested in the replicated tests only one season; it proved entirely inadequate for the control of gray leaf spot, and plots sprayed with it produced the lowest yield of marketable fruit of any of the fungicide-sprayed plots that season. The differences between the yield of the copper-sprayed plot and those of plots sprayed with zineb; nabam + $MnSO_4$, or maneb were significant at the 5 percent level.

Bacterial spot control with streptomycin was tested in the 1955 fall field test, when streptomycin was applied as a separate application to one-half of each plot on a split-plot basis approximately once a week. Following inoculation of the plants with the bacterial spot organism, 6 percent of the fruit picked from the plants sprayed with the antibiotic showed bacterial spot lesions, whereas 19 percent of those picked from plants sprayed with fungicides only showed symptoms of the disease. This difference was significant at the 1 percent level when the percentages were converted to angles, as suggested by Snedecor (11), and analyzed. During the same season, in a cooperative test with a local grower, no difference in the amount of bacterial spot was noted between blocks sprayed with nine applications of any one of the following treatments: basic copper sulfate; glycerol, 8 pounds per 100 gallons plus 100 ppm (first six applications) and 200 ppm (last three applications) streptomycin; neutral copper + streptomycin at above concentrations; streptomycin alone at double the above concentrations.

The plants sprayed with glycerol + streptomycin showed a yellow mottling of the leaves followed by some leaf necrosis, particularly of the lower leaves. Bio-assay of juice extracted from leaves collected from injured plants indicated that the injury was due to the glycerol rather than to the absorption of streptomycin to a phytotoxic level.

Several seedbed tests were conducted, but only in the 1956 fall test was the incidence of disease and nature of the data such that a statistical analysis could be conducted (Table 2). The use of 400 ppm streptomycin in the first two applications of copper followed by 100 ppm streptomycin + copper did not improve control over that obtained with 100 ppm + copper used throughout the time that the plants were in the seedbed. Streptomycin at 200 ppm and streptomycin at 100 ppm + glycerol gave intermediate control whereas streptomycin at 100 ppm or the two copper fungicides failed to control the disease.

DISCUSSION

The consistently inferior yields obtained from plants sprayed with nabam + $ZnSO_4$, as compared with plants sprayed with other effective carbamate fungicides, supports the results of Conover (5). Consequently, it is suggested that Conover's recommendation that nabam + $ZnSO_4$ should not be used on tomatoes be extended to include the west coast area of Florida and possibly the entire State.

The excellent control of gray leaf spot given by Dyrene indicates that this new fungicide would be a useful addition to the list of currently recommended tomato fungicides. Dyrene's failure to give adequate control of late blight, however, requires caution in its use after late blight has appeared in an area.

The failure of copper fungicides to control bacterial spot under the severe conditions of the 1957 spring seedbed test demonstrates that a more effective control of this disease is needed. Control was improved when 200 ppm streptomycin was used. The use of 100 ppm streptomycin + neutral copper gave still better control and represents the most economical control obtained in these tests.

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A METHOD FOR TESTING SEEDLING PROGENIES OF POTATO FOR RING-ROT RESISTANCE

Reiner Bonde, Robert Akeley, and Donald Merriam[1]

Abstract

Young potato plants grown from true seed were inoculated by dipping their roots in a heavy slurry of ring-rot inoculum and then planting directly into 3-inch pots in the greenhouse. Symptoms of infection appeared 30 to 50 days after inoculation. The method has been successfully used to screen out ring-rot-susceptible seedlings in a breeding program.

Research conducted in Maine on the inheritance of resistance to infection by the ring rot organism (Corynebacterium sepedonicum) has been made mostly with seedlings previously selected for desirable horticultural and marketing qualities. Testing unselected populations of different crosses in large numbers for their reaction to ring rot will give more information on the breeding behavior of different parents.

In the past, ring-rot resistance studies were usually made with seedpieces of seedling tubers inoculated by dipping in a heavy slurry made from infected tubers. Immediately after inoculation the seedpieces were planted either in the field or in the greenhouse. The extent of infection was determined by macroscopic observations 100 to 120 days after inoculation.

In the present test the potato seeds were planted in flats of heat-sterilized soil in the greenhouse. The seedlings were removed from the flats when they were 1 to 2 inches high and were inoculated by dipping their roots in a heavy slurry of ring-rot inoculum. The inoculated seedlings were immediately transplanted into 3-inch pots (Fig. 1). The infection was apparent 30 to

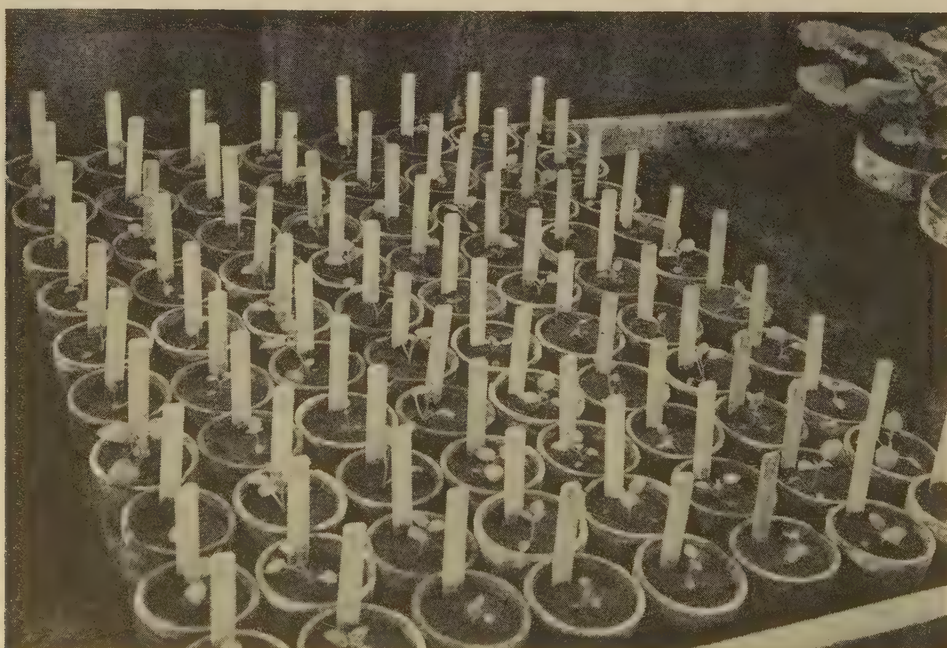

FIGURE 1. Potato seedlings inoculated with ring-rot bacteria from decayed tubers and planted in pots in the greenhouse.

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50 days after inoculation. Comparison of susceptible and resistant plants 60 days after each was inoculated is shown in Figure 2.

FIGURE 2. Susceptible (left) and resistant (right) potato seedling plants 60 days after each was inoculated with ring-rot bacteria.

Table 1. Resistance of seedlings of potato progenies to ring rot obtained by the root-inoculation method, Maine, 1957.

Pedigree number	Parentage	Number tested	Resistant to ring rot (number)	Resistant to ring rot (percent)
B 4384	Katahdin (S) x B 355-24 (R)[a]	52	15	29
B 4385	B 721-1 (R) x Menominee (S)	93	2	2
B 4386	B 721-1 (R) x B 355-24 (R)	148	18	12
B 4387	B 2131-3 (S) x Menominee (S)	45	0	0
B 4388	B 3139-24 (R) x B 355-24 (R)	36	1	3
B 4389	Merrimack (R) x B 721-1 (R)	43	4	9
B 1539	Katahdin (S) selfed	39	3	8
B 1540	Menominee (S) selfed	42	5	12
B 1541	B 355-24 (R) selfed	67	26	39
B 1542	B 721-1 (R) selfed	48	25	50
B 1543	B 2131-3 (S) selfed	58	4	7
-	Cherokee (S) Nat. Pol.[b]	32	10	31
-	Saranac (R) Nat. Pol.	39	18	46
-	B 24-58 (S) Nat. Pol.	29	3	10
-	B 319-Me. 1 (R) Nat. Pol.	60	28	49

[a] R = resistant; S = susceptible.

[b] Seed from seedballs naturally fertilized in the field.

The data in Table 1 summarize the results of inoculations made in 1957. Fifteen progenies obtained from six crosses, five selfs, and four lines naturally pollinated in the field were tested. The results from this root-inoculation method are similar to those usually obtained from a seedpiece-inoculation method of related parents, varieties, and seedlings (Bonde, unpublished data). Also, by use of this method susceptible seedlings can be detected and removed from segregating family lines in a shorter time.

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A REVIEW OF UNIFORM DOSAGE AND TIMING EXPERIMENTS COMPARING MANEB AND ZINEB FUNGICIDES ON POTATOES IN MAINE, NEW YORK, INDIANA AND NEW HAMPSHIRE--1958[1]

Gordon A. Brandes[2], Reiner Bonde[3], R. C. Cetas[4], R. W. Samson[5], A. E. Rich[6]

Summary

Several dosage levels of maneb were compared to the standard dosage of tank mix zineb (nabam plus zinc sulfate) at 5, 7 and 10 day spray intervals in four different locations on five varieties of potatoes in 1958. All treatments were applied in 100 gallons of water per acre. In general, the nabam standard was superior to 0.5 pound of maneb, about equal to 1.0 pound of maneb and inferior to 1.5 or 2.0 pounds of maneb for the control of late blight or of early blight. There was very little difference between treatments at the 5-day spray interval, but the superiority of maneb at 1.5 or 2.0 pound rates was more pronounced at the 7 day, and especially at the 10 day interval. In general, yield increases correlated well with disease control. Rates of 1.5 and 2.0 pounds of maneb per acre provided superior disease control and higher potato yields than 2 quarts of nabam plus zinc sulfate especially under severe disease conditions or at extended spray intervals.

DETAILS

A uniform fungicide experiment was conducted on potatoes at four locations; that is, Presque Isle, Maine; Riverhead, Long Island, New York; Wanatah, Indiana; and Durham, New Hampshire; in 1958. Dosage of maneb[7], from 0.5 to 2.0 pounds per acre and the standard dosage rate of tank mix zineb (2 quarts nabam[8] plus 0.75 pound zinc sulfate[9]) were compared at 5, 7, and 10 day spray intervals. Sprays were applied at approximately 100 gallons per acre. Each test was randomized and replicated four or more times. Recommended insecticides were applied uniformly to all plots in separate applications, when needed.

INDIVIDUAL EXPERIMENTS

Presque Isle, Maine

Variety Katahdin planted May 17, harvested September 24. Randomized split block design, plots four rows wide, 36 inches apart, 50 feet long, four replicates. High pressure sprayer 350 psi, hand boom on hoses operated manually, 100 gallons spray per acre.

Riverhead, New York

Variety Green Mountain, planted June 26, harvested October 15, randomized split block design, plots three rows wide, 34 inches apart, 45 feet long, four replicates. High pressure

[1] Uniform Fungicide trials conducted by [3]Reiner Bonde, University of Maine, Presque Isle, Maine; [4]R. C. Cetas, Cornell University, Long Island Vegetable Research Farm, Riverhead, New York; [5]R. W. Samson, Purdue University, Lafayette, Indiana; [6]A. E. Rich, University of New Hampshire, Durham, New Hampshire. This work supported in part by grants-in-aid from the Rohm & Haas Company. Published with the approval of the Director of the New Hampshire Experiment Station as Scientific Contribution No. 235.
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[2] Agricultural and Sanitary Chemicals Department, Rohm & Haas Company, Philadelphia, Pennsylvania.
[7] Dithane M-22 -- 70% manganese ethylenebisdithiocarbamate -- Rohm & Haas Company.
[8] Dithane D-14 -- 22% disodium ethylenebisdithiocarbamate -- Rohm & Haas Company.
[9] Zinc sulfate monohydrate -- contains 36% metallic zinc equivalent.

power sprayer, 400 psi, three over-head nozzles per row, brush boom, 100 to 125 gallons spray per acre.

Wanatah, Indiana

Varieties Sebago, Red Pontiac, Russet Burbank, planted May 13, harvested October 10. Randomized block design, plots were single row 5.5 feet apart, each variety subplot 17 feet long, total plot length 51 feet, four replicates. High pressure sprayer 250 psi, three nozzles per row, drop boom, 100 gallons per acre. Plots grown on muck soil irrigated by sprinklers with 2 acre-inches of water in May and in August.

Durham, New Hampshire

Variety Green Mountain, planted May 31, harvested October 10, randomized split block design. Individual plots consisted of four hills of potatoes planted in a square 6 feet apart, six replicates. Application made with hand sprayer at 30-40 psi with full coverage.

Table 1 summarizes the dates of initial and final spray applications and the total number of applications for each spray interval at each location.

Table 1. Summary of spray applications.

Location	Initial application	Final application	Total sprays per season: 5-day interval	7-day interval	10-day interval	Vines killed	Harvest date
Maine	7/12	9/10, 9/8, 9/5	15	10	7	9/15	10/1
New York	7/21	10/4, 10/6, 9/29	15	12	8	10/8	10/15
New Hampshire	7/7	9/25, 9/22, 9/25	17	12	9	9/30	10/10
Indiana	7/9	9/8, 9/2, 9/8	13	9	7	--	10/10

WEATHER AND DISEASE CONDITIONS

Generally cool temperatures with frequent rainfall were conducive to natural epiphytotics of late blight, Phytophthora infestans, in Maine and New York, and of early blight, Alternaria solani, in Indiana. Artificial inoculation with late blight was used in the New Hampshire experiment and some early blight was present, but the infections developed slowly and only very late in the season. Defoliation readings using the Horsfall & Barratt scale were made periodically. Percent diseased foliage was estimated by reading from a graph of the Horsfall & Barratt rating scale on three cycle semi-log paper.

DISEASE CONTROL OBSERVATIONS

Maine

One to two percent defoliation was recorded in the untreated controls on August 22 with trace amounts in nabam at all intervals and in the 0.5, 1.0 and 1.5 pound rates of maneb at 10 days. By September 6 defoliation had increased in the controls to 59, 65, and 80 percent and to 1, 6, and 8 percent in the nabam treatment at the 5, 7 and 10 day intervals, respectively. All maneb treatments showed less than 1 percent defoliation except the 0.5 pound rate at 10 days which was 2 percent.

Final defoliation readings made on September 15 are shown in Figure 1. No appreciable increase occurred between September 6 and September 15 in any maneb treatments or in the nabam treatment at 5 and 7 days. However, final defoliation in the nabam treatment at 10 days increased to 15 percent and the controls went to an average of 85 percent. Defoliation control with all maneb treatments was superior to nabam at all spray intervals.

New York

Late blight was noted in the untreated controls on August 14. The first defoliation ratings were made on September 1; the checks averaged 53 percent and the treatments ranged from less than 1 to 8 percent. Weather conditions were extremely favorable for the spread of late blight and a heavy load of inoculum was present in the outside, unsprayed buffer rows and in the several checks and poor treatments. On September 12, the greatest difference between treatments and the controls could be seen. The untreated controls averaged 99 percent defoliation and blight was spreading rapidly in the 0.5 pound maneb treatments at all spray intervals.

All spray treatments gave significantly better disease control than the untreated. The 0.5 pound maneb treatment was poorer and the 2.0 pound maneb treatment was superior to other treatments at all spray intervals. The differences between rates of 1.0 and 1.5 pounds of maneb and 2 quarts of nabam-zinc sulfate were within the limits of experimental error, how-

ever, the 1.5 and 2.0 pound rates of maneb had the lowest average disease readings. The amount of disease increased with each treatment as the spray interval was lengthened from 5 to 7 or from 7 to 10 days. Disease conditions were so favorable within the test plot area that by October 4 the difference between treatments and controls at 7 and 10 days largely disappeared. Details of foliage disease ratings for September 12 are shown in Figure 2.

Indiana

Early blight was the only foliage disease present in this test. Final defoliation readings made on September 9 are shown in Figures 3 to 6. The three varieties used showed a differential susceptibility to early blight defoliation, especially in the untreated checks. Untreated controls averaged 89 percent defoliation in Red Pontiac, 85 percent in Russet Burbank and 26 percent in Sebago. All treatments at all spray intervals, except 0.5 pound maneb were significantly better than the unsprayed check in all varieties separately and collectively. The same treatments gave a relatively higher level of control on Russet Burbank than on Red Pontiac even though the disease level in the untreated checks was about the same for each variety. A possible explanation for this difference in control may be due to the vigorous, robust nature of the Pontiac foliage as compared to the more finely stemmed and small leafed foliage of the Russet Burbank which permitted more thorough spray coverage of the latter variety.

Sebago: There was no difference between any of the maneb treatments and the standard nabam-zinc sulfate at the 5 and 7 day interval. At the 10 day interval the 1.0, 1.5, and 2.0 pound maneb treatments were superior while the 0.5 pound rate was equal to nabam-zinc sulfate.

Red Pontiac: 0.5 pound maneb was inferior to nabam at 5 and 7 days. All other treatments were equal except 1.5 pounds maneb at 7 days and 2 pounds maneb at 10 days which were superior to nabam.

Russet Burbank: All maneb treatments were equal to nabam at 5 and 7 days. At 10 days 0.5 pound maneb was inferior, 1 pound was equal and 1.5 and 2 pounds were superior to nabam.

All Varieties: When all three varieties were averaged, 1.0 pound of maneb at 5, 7, and 10 days, 1.5 pounds maneb at 5 days, and 0.5 pound maneb at 10 days were equal to the standard nabam. 1.5 pounds maneb at 7 and at 10 days and 2 pounds maneb at 10 days were significantly better than the standard. When all varieties and spray intervals in the Indiana test were averaged, 0.5 pound of maneb was inferior, 1 pound was equal and 1.5 pounds was superior to 2 quarts of nabam-zinc sulfate for the control of early blight defoliation. (Figures 3 to 6).

New Hampshire

Even with artificial inoculation of late blight and a light natural infection of early blight, the diseases developed very slowly in these plots. At the time of final readings on September 30, the untreated controls averaged 67 percent defoliation and treatments ranged from 11 to 21 percent. All treatments were significantly better than the controls, but differences between treatments were within the limits of experimental error, except 0.5 pound maneb which was inferior in the 10 day schedule. When all treatments and intervals were averaged, the decreasing order of effectiveness was 1.5 pounds maneb, 2 quarts nabam-zinc sulfate, 1 pound maneb and 0.5 pound maneb. Details are shown in Figure 7.

A summary of defoliation data for all four locations is shown in Figure 8.

YIELD DATA

Yields were normal in Maine, Indiana and New Hampshire, but well below average expectancy in New York. In general, there was fairly good correlation between yields and the amount of defoliation although the influence of other factors, such as soil variability and microtopography was evident in certain individual plots. There was no evidence of phytotoxicity from any of the maneb or nabam-zinc sulfate treatments. Yield increases in bushels per acre over the untreated are shown graphically in Figures 9 through 15.

Maine

All treatments gave significantly higher yields than the unsprayed controls and all maneb treatments were significantly better than the nabam-zinc sulfate standard at odds of 99.1.

FIGURE 1. MAINE - LATE BLIGHT - SEPT. 15, 1958

PERCENT DISEASE AND HORSFALL & BARRATT RATING (IN PARENTHESIS)

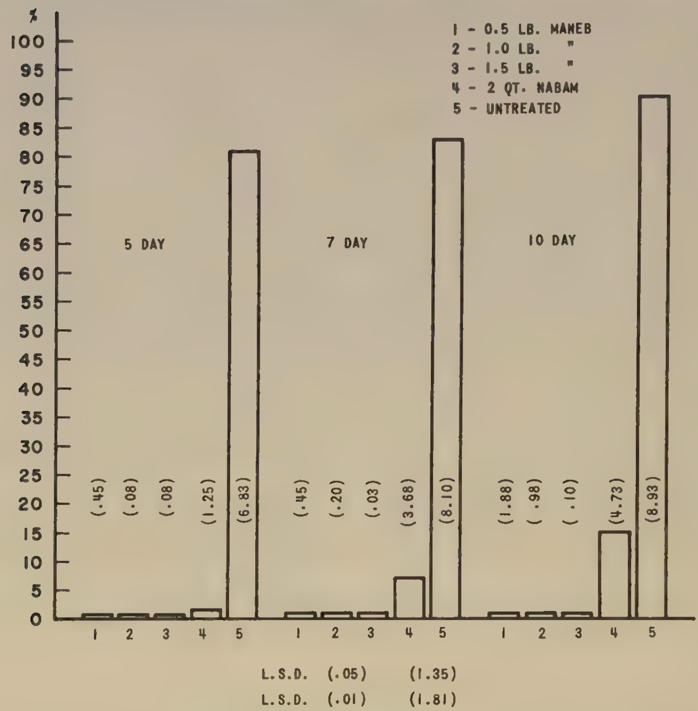


FIGURE 2. NEW YORK - LATE BLIGHT - SEPT. 12, 1958

PERCENT DISEASE AND HORSFALL & BARRATT RATING (IN PARENTHESIS)

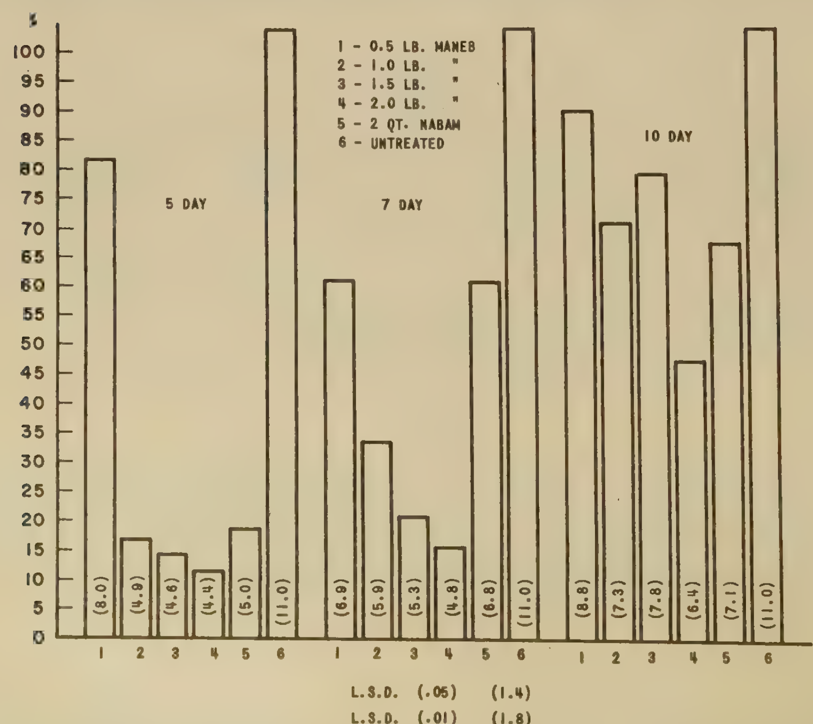
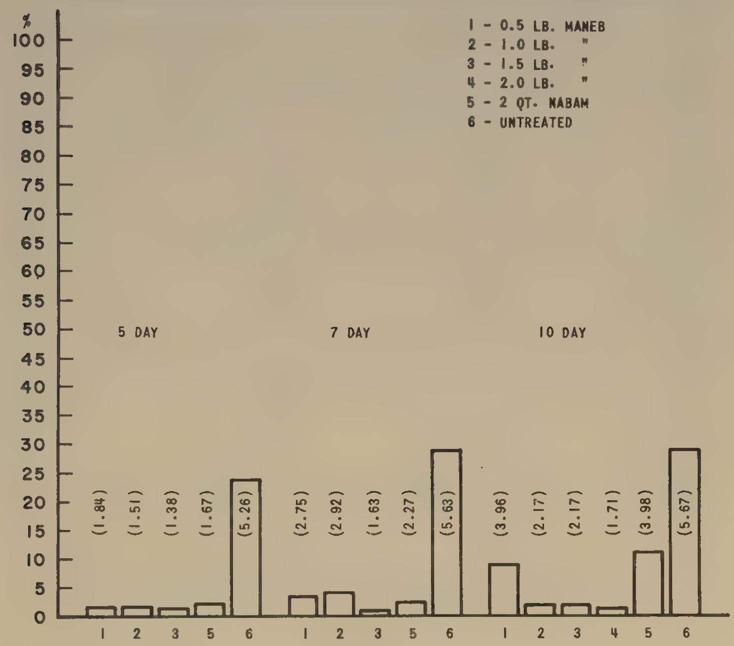
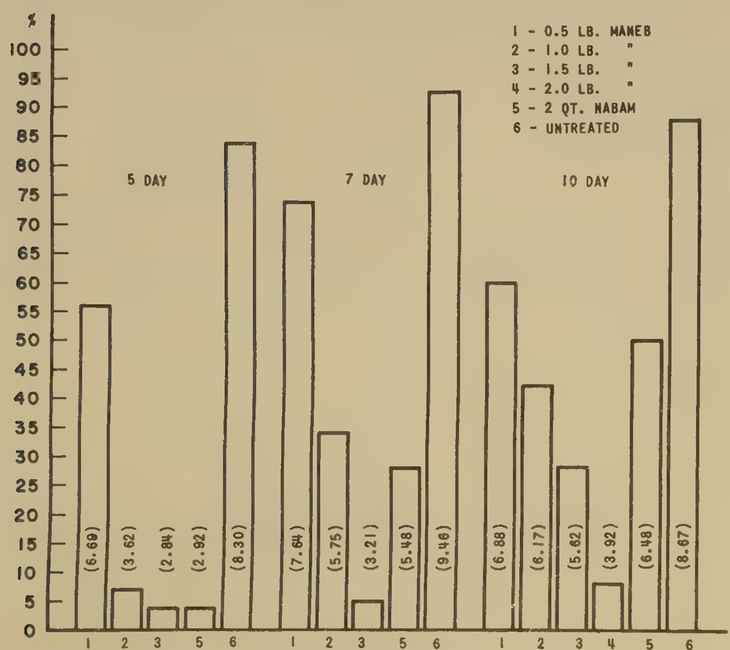


FIGURE 3. INDIANA, SEBAGO, EARLY BLIGHT - SEPT. 9, 1958
PERCENT DISEASE AND HORSFALL & BARRATT RATING (IN PARENTHESES)



L.S.D. (.05) (1.05)
L.S.D. (.01) (1.40)

FIGURE 4. INDIANA - RED PONTIAC, EARLY BLIGHT - SEPT. 9, 1958
PERCENT DISEASE AND HORSFALL & BARRATT RATING (IN PARENTHESIS)



L.S.D. (.05) (1.87)
L.S.D. (.01) (2.50)

FIGURE 5 - INDIANA, RUSSET BURBANK, EARLY BLIGHT - SEPT. 9, 1958

PERCENT DISEASE AND HORSFALL & BARRATT RATING (IN PARENTHESIS)

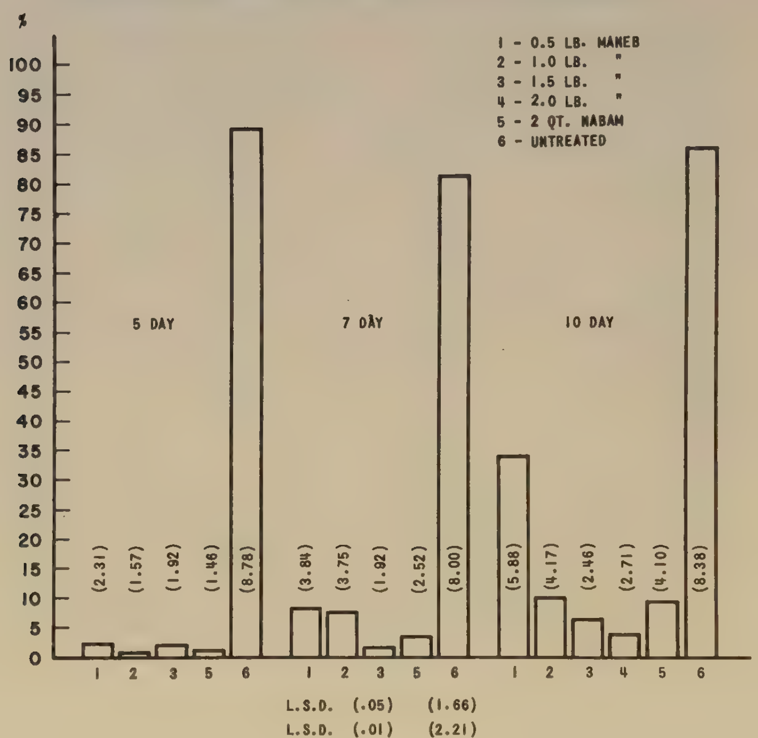


FIGURE 6. INDIANA, AVERAGE 3 VARIETIES, EARLY BLIGHT - SEPT. 9, 1958

PERCENT DISEASE AND HORSFALL & BARRATT RATING (IN PARENTHESIS)

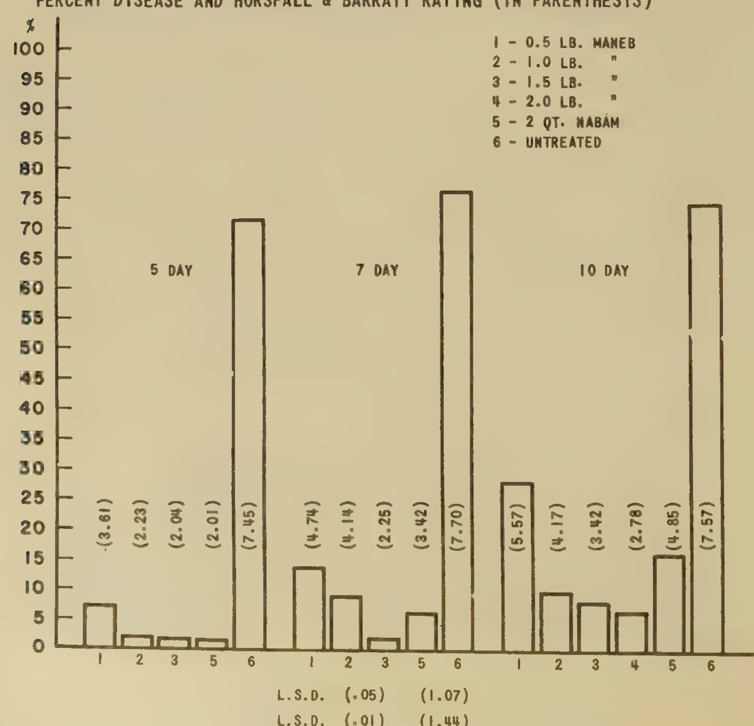
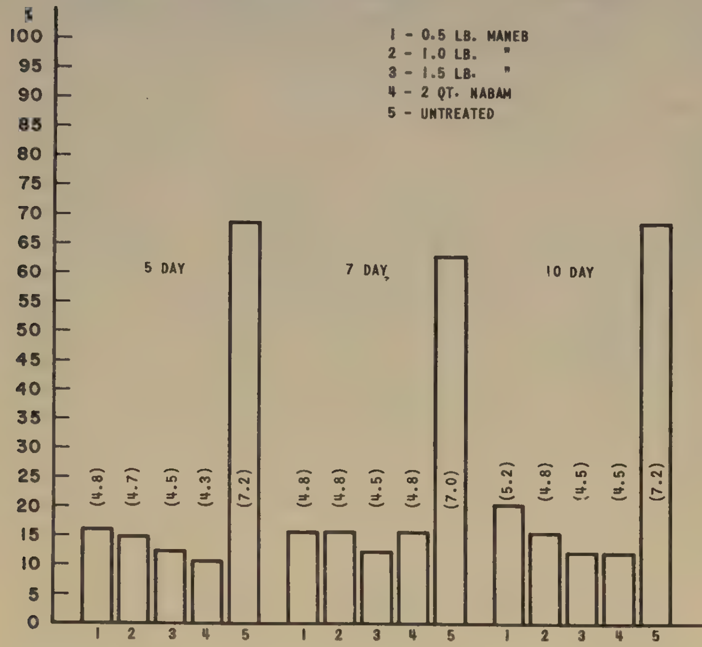


FIGURE 7. NEW HAMPSHIRE, LATE & EARLY BLIGHT - SEPT. 30, 1958

PERCENT DISEASE AND HORSFALL & BARRATT RATING (IN PARENTHESIS)



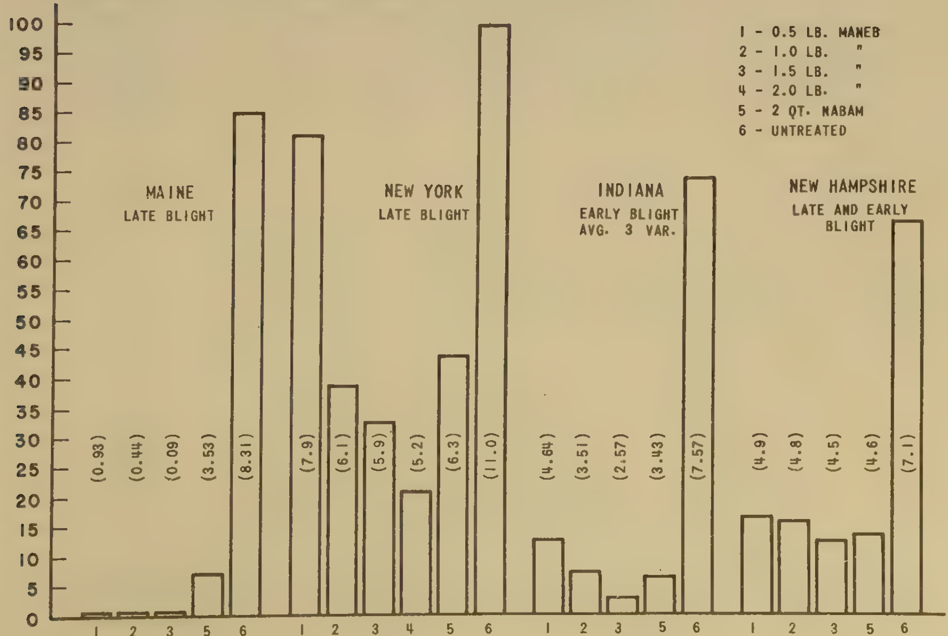
L.S.D. (.05) (0.7)

L.S.D. (.01) (0.9)

FIGURE 8. SUMMARY OF FOUR LOCATIONS

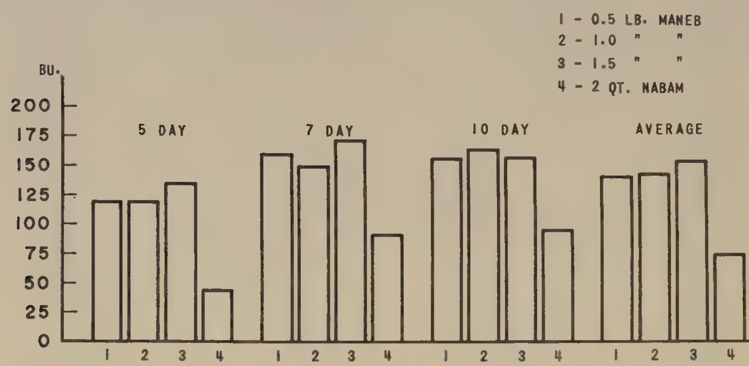
PERCENT DISEASE AND HORSFALL & BARRATT RATING (IN PARENTHESIS)

% AVERAGE OF 5, 7, AND 10 DAY SPRAY INTERVALS



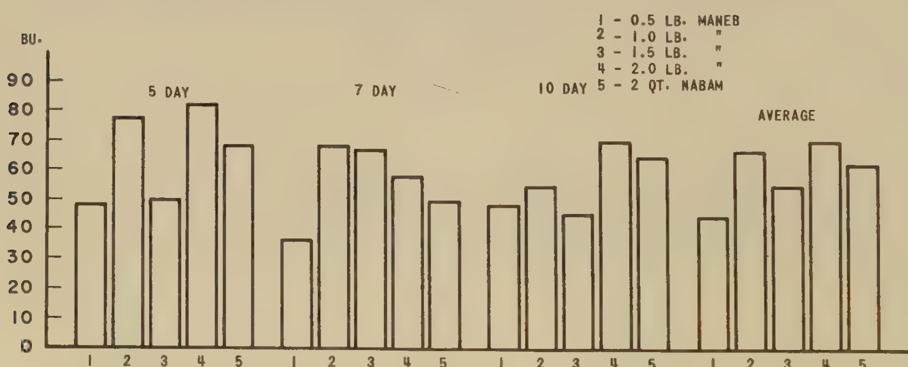
L.S.D.	(.05)	(0.78)	(0.8)	(0.62)	(0.4)
L.S.D.	(.01)	(1.05)	(1.1)	(0.83)	(0.5)

FIGURE 9. YIELD - MAINE
(INCREASE IN BUSHELS PER ACRE OVER UNTREATED)



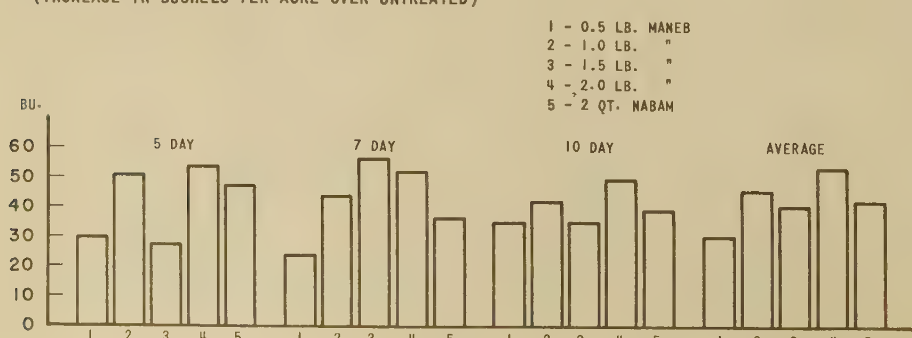
	5 DAY	7 DAY	10 DAY	AVERAGE
YIELD BU./A. UNTREATED	524	473	485	494
L.S.D. (.05)	48	48	48	28
L.S.D. (.01)	64	64	64	37

FIGURE 10. YIELD - NEW YORK - TOTAL BUSHELS PER ACRE
(INCREASE IN BUSHELS PER ACRE OVER UNTREATED)



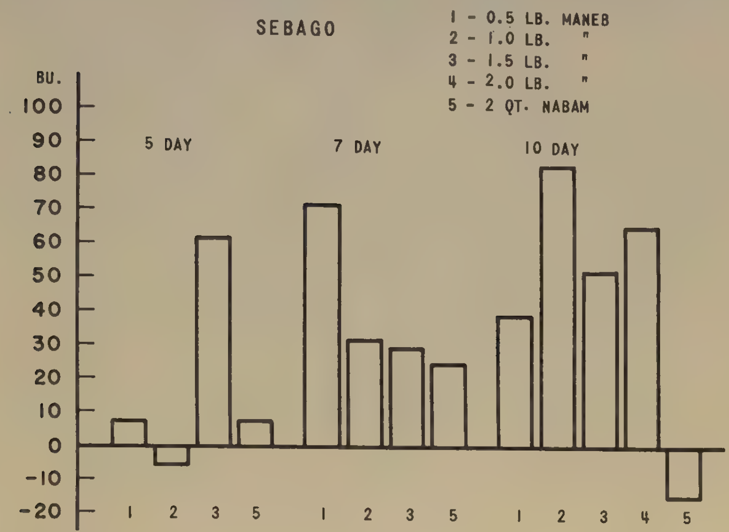
	5 DAY	7 DAY	10 DAY	AVERAGE
YIELD BU./A. UNTREATED	38	48	31	39
L.S.D. (.05)	43	43	43	25
L.S.D. (.01)	58	58	58	33

FIGURE 11. YIELD - NEW YORK - U. S. NO. 1'S PER ACRE
(INCREASE IN BUSHELS PER ACRE OVER UNTREATED)



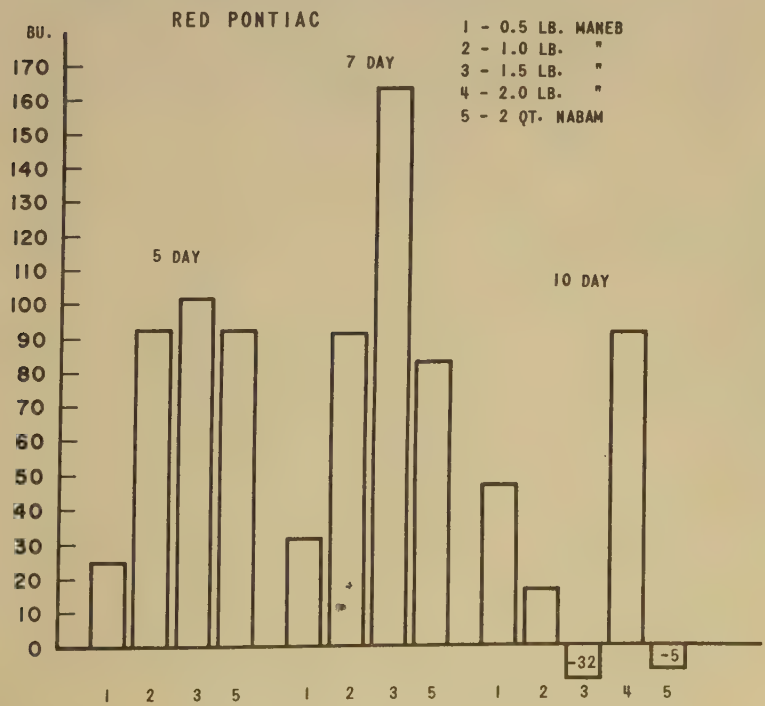
	5 DAY	7 DAY	10 DAY	AVERAGE
YIELD BU./A. UNTREATED	25	24	13	20
L.S.D. (.05)	26	26	26	15
L.S.D. (.01)	35	35	35	20

FIGURE 12. YIELD - INDIANA
(INCREASE IN BUSHELS PER ACRE OVER UNTREATED)



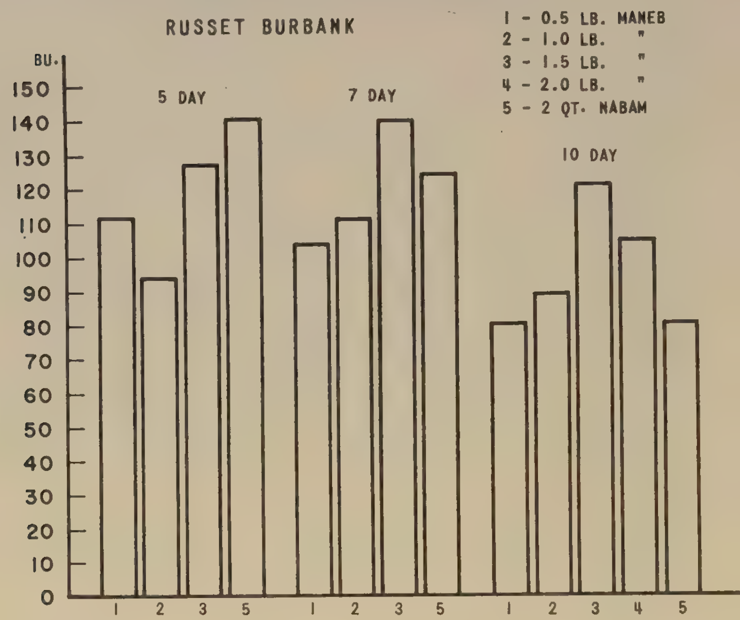
YIELD BU./A. UNTREATED	410	393	371
L.S.D. (.05)	65	65	65
L.S.D. (.01)	88	88	88

FIGURE 13. YIELD - INDIANA
(INCREASE IN BUSHELS PER ACRE OVER UNTREATED)



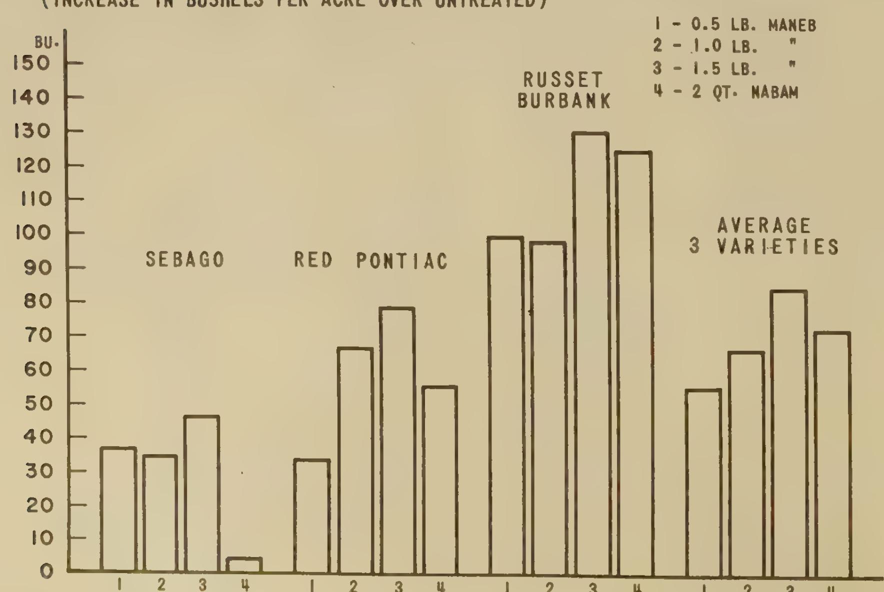
YIELD BU./A. UNTREATED	346	332	367
L.S.D. (.05)	66	66	66
L.S.D. (.01)	88	88	88

FIGURE 14. YIELD - INDIANA
(INCREASE IN BUSHELS PER ACRE OVER UNTREATED)



YIELD BU./A. UNTREATED	313	301	306
L.S.D. (.05)	71	71	71
L.S.D. (.01)	94	94	94

FIGURE 15. YIELD - INDIANA - AVERAGE OF 5, 7, 10 DAY SPRAY INTERVALS
(INCREASE IN BUSHELS PER ACRE OVER UNTREATED)



YIELD BU./A. UNTREATED	391	348	307	349
L.S.D. (.05)	75	76	82	39
L.S.D. (.01)	99	102	109	53

When averaged, the maneb treatments outyielded nabam by 72 bushels and the untreated by 147 bushels per acre. Nabam treatments averaged 75 bushels per acre more than the untreated. There was no significant difference between treatments associated with the various spray intervals. The 1.5 pound rate of maneb yielded slightly more than the 1 pound and 0.5 pound rate, though the difference was not significant (Figure 9).

New York

The Green Mountain variety normally requires 140 days for full maturity under Long Island, New York conditions. This test was purposely planted late (June 26) to favor late blight development. The vines were killed in approximately 110 days. Thus, the yields were abnormally low and it may be difficult to draw reliable conclusions from such data. Check plots averaged only 39 bushels total yield and 20 bushels of U.S. No. 1 tubers per acre. The highest yielding treated plot produced 120 bushels total yield per acre. Excess rainfall caused portions of the test area to have water standing in the rows in low spots at various times, and also caused some deviation from the proposed scheduling of spray applications. This apparently affected yields of certain plots in addition to that associated directly with late blight defoliation. In general, yields were lower in treatments applied every 10 days than at the shorter intervals but the differences were not statistically significant. When all spray intervals were averaged, the decreasing order of effectiveness for treatments in both total yield and yield of U.S. No. 1's was 2.0 pounds maneb, 1.0 pound maneb, 2 quarts nabam-zinc sulfate, 1.5 maneb, 0.5 maneb, and untreated, with all spray treatments being significantly better than the check. The position of the 1.5 pound maneb treatment is inconsistent with general experience (Figures 10 and 11).

Late blight tuber rot was scored at harvest. Again the effect of location is evidenced in certain plots, and some apparent inconsistencies can be seen in individual treatments. Certain generalizations can be made from the data presented: 2.0 pounds of maneb showed the least tuber rot of any treatment; there was less rot in the 5 day schedule than at 7 or 10 days for all treatments and especially in the nabam treatments; when averaged, the amount of rot decreased as the dosage of maneb increased, and all maneb treatments except the 0.5 pound rate had less tuber rot than the standard nabam-zinc sulfate. Rot in the untreated check was relatively low because these plots were defoliated during a period when no heavy rainfall occurred. Correlations between defoliation and tuber rot are difficult to make in many potato fungicide experiments. This seems to be the case in this instance when isolated treatments are examined, but when the average amount of rot is compared with the average defoliation per treatment, the same general trends were revealed.

Detailed data are presented in Table 2.

Table 2. Late blight tuber rot at harvest, New York.

Treatment	Amount/100 gallons	Bushels per acre with various spray schedules			
		5 days	7 days	10 days	Average
Maneb	0.5 pound	2.1	13.5	6.2	7.3
Maneb	1.0 pound	3.6	5.8	3.6	4.3
Maneb	1.5 pounds	1.3	4.5	1.9	2.6
Maneb	2.0 pounds	0.0	0.2	0.0	0.1
Nabam + $ZnSO_4$	2.0 quarts	1.9	4.5	10.2	5.6
Untreated	--	0.0	5.3	4.3	3.2
LSD .05		(6.2)	(6.2)	(6.2)	(3.6)
LSD .01		(8.4)	(8.4)	(8.4)	(4.8)

Indiana

There was considerable plot to plot variation in the yields in this experiment which required relatively high values for statistical significance. On the whole, there was good correlation between defoliation control and yield.

Sebago: This variety had the lowest defoliation ratings. The untreated yield was rela-

tively high and only isolated treatments showed any statistically significant increase over the control. When all Sebago spray intervals were averaged the 0.5 pound and 1.5 pound maneb treatments with increases of 38 and 47 bushels per acre, respectively, were significantly better than the check and the 1.0 pound rate with 36 bushels increase was nearly so. The standard nabam treatment yielded 6 bushels more per acre than the check, but the difference was not significant (Figure 12).

Red Pontiac: There were significant increases in yield of 82 and 164 bushels per acre over the check for 1.0 pound maneb, 1.5 pounds maneb, and nabam at 5 and 7 days and for 2.0 pounds maneb at 10 days. The 0.5 pound maneb treatment at all intervals, and the 1.0 and 1.5 pound maneb and 2 quart nabam treatment at 10 days were not significantly different than the check. When all spray intervals were averaged, the decreasing order of performance was: 1.5 pounds maneb, 1.0 pound maneb, 2 quarts nabam, 0.5 pound maneb and the untreated (Figure 13).

Russet Burbank: All treatments gave highly significant increases in yield ranging from 80 to 141 bushels per acre over the checks but there was no significant difference between spray treatments. With the exception of 1.0 pound maneb at 5 days and 2.0 pounds of maneb at 10 days, the yields of maneb plots increased with each dosage increase. However, Dr. Samson expressed some skepticism over the low yield of the 2.0 pounds maneb, 10 day treatment because it gave highly significant control of defoliation. Nabam-zinc sulfate gave the highest yield at 5 days and was below 1.5 pounds maneb at 7 and 10 days, but the differences were within the limits of experimental error (Figure 14).

All Varieties: Yield increases were generally greater with 5 day as compared with 7 day spray intervals and with 7 day as compared with 10 day intervals for Red Pontiac and Russet Burbank varieties, but the reverse was true for Sebago. As was noted before, the disease level was much lower in Sebago than in the other varieties and the yield of the Sebago untreated checks was highest in 5 days and decreased 17 bushels at 7 days and 39 bushels at 10 days. The increases in yield over untreated were lowest for Sebago, intermediate for Red Pontiac, and highest for Russet Burbank. These differences were well correlated with the severity of the disease and the degree of control afforded by the treatments.

When all spray intervals were averaged for each separate variety, 1.5 pounds maneb gave the highest yield increase. When all spray intervals and all varieties were averaged, the highest yield increase over untreated was recorded for 1.5 pounds maneb, followed by the standard nabam-zinc sulfate, 1.0 pound maneb, and 0.5 pound maneb (Figure 15).

New Hampshire

There were no significant yield differences in this experiment between treatments or spray intervals. The disease level was low in this test and it developed too late in the season to have much effect on yields.

GENERAL REMARKS AND OBSERVATIONS

This series of uniform cooperative tests was undertaken to compare the fungicidal effectiveness of an improved maneb fungicide and the widely used standard potato fungicide in the United States and Canada, nabam-zinc sulfate. The range of maneb dosages was selected on the basis of earlier comparisons which would be expected to give performance below and above the standard treatment. The spray interval comparison was superimposed on the dosage comparison because fungicidal performance is based not only on fungitoxicity, but on persistence as well. Four widely separated areas were chosen because they were known to have consistent records of high disease incidence, and would provide different environmental conditions. Five different varieties were employed, and each of the two common potato blights was encountered. Although an attempt was made to keep the technique of spray applications as uniform as possible, there were differences at each location. All things considered, this was a very useful and informative set of experiments. It is notable that the same trends in disease control and yield increase were generally noted in each separate investigation. Further trials employing uniform dosage and spray intervals would be worthwhile for plant pathologists on a regional or even on a national basis.

ROHM & HAAS COMPANY, PHILADELPHIA, PENNSYLVANIA, AND THE AGRICULTURAL EXPERIMENT STATIONS OF MAINE, NEW YORK, INDIANA AND NEW HAMPSHIRE

THE EFFECTS OF STORAGE OF VEGETABLE SEEDS TREATED WITH FUNGICIDES AND INSECTICIDES ON GERMINATION AND FIELD STAND[1]

D. J. deZeeuw, G. E. Guyer, A. L. Wells, and R. A. Davis[2]

Abstract

Seeds of Alderman Peas, Round Pod Kidney wax beans, and National Pickling cucumbers were treated in 1956 with various fungicide and insecticide materials. Field plantings and laboratory germinations were made of each treatment in 1956, 1957, and 1958. Results of field stands of the three crops for the 3 years indicated that organic fungicides alone and in combination with certain insecticides were superior to the mercury materials and to insecticides alone. The insecticides, as a group, were injurious to stands of beans but had little deleterious effect on the emergence of peas or cucumbers. An increase in damage caused by storage of the treated seed was not apparent. The phytotoxicity to peas and beans from the volatile type mercury materials increased with length of storage. Germination tests, based on observations of root and shoot emergence, did not reflect the injury that was noted in the field plantings.

Seed treatment of vegetable seeds with fungicides and insecticides often results in germination injury and, consequently, poor stands. The effects may be more severe when storage is prolonged or when storage conditions are generally unfavorable for the seed (1, 2, 8, 9, 10, 11). In general insecticides are more injurious to seeds than are fungicides. This is particularly true when treated seeds are planted in cold soils. It is advisable to combine the insecticide with a fungicide to minimize injury by the insecticide component (6, 7). In 1956 an experiment was initiated to determine the effects of storage of bean, pea and cucumber seeds treated with various fungicides and insecticides and combinations of both.

MATERIALS AND METHODS

Seeds of Alderman peas, Round Pod Kidney wax beans, and National Pickling cucumbers were weighed out in treatment lots for three annual field trials and three laboratory germination tests. Insofar as possible each field planting consisted of six randomized plots of 100 seeds per treatment. The germinations were based on 50 seeds per treatment each year. The materials were applied to the seed approximately 5 weeks prior to the initial planting in 1956. The materials tested, with their active ingredients and manufacturers, are given in Table 1. In all cases the samples for planting were counted and packaged as near planting time as was practical. Between trials the seed stocks were held in unheated dry storage and protected from insects and rodents. Germination tests were made in moist rolls of paper toweling in wide mouth glass jars held at 80° F for 5 to 7 days. All seeds displaying an emerging root and shoot were counted as viable.

The schedule for planting and counting field stands of the healthy surviving plants was:

Variety	Date planted	Date counted
Peas	May 25, 1956	June 12, 1956
	May 9, 1957	June 14, 1957
	May 8, 1958	June 17, 1958
Beans	June 2, 1956	June 22, 1956
	May 28, 1957	June 18, 1957
	May 28, 1958	June 26, 1958

[1]Published with the approval of the Director as Journal Article No. 2362, Michigan Agricultural Experiment Station. No. 58-39 of the Department of Botany and Plant Pathology.

[2]Departments of Botany and Plant Pathology, Entomology, Entomology, and Botany and Plant Pathology.

Variety	Date planted	Date counted
Cucumbers	June 20, 1956	July 4, 1956
	June 6, 1957	June 25, 1957
	June 5, 1958	July 1, 1958

Table 1. Materials evaluated, their active ingredients and manufacturer.

Treatment number	Name	Composition and manufacturer
Insecticides		
1	Dieldrin 50%	50% wettable powder. 1, 2, 3, 4, 10, 10 hexachloro-6, 7-epoxy-1-4, 4a, 5, 6, 7, 8, 8a-1, 4, 5-endoexo-octahydro-dimethanonaphthalene. Shell Chemical Corp.
2	Dieldrin 24%	24% solution in organic solvent. Panogen, Inc.
3	Heptachlor	50% wettable powder. 3a, 4, 5, 6, 7, 8, 8a-heptachloro-3a, 4, 7, 7a-tetrahydro-4, 7-methanoindene. Velsicol Chemical Corp.
4	Aldrin	25% wettable powder. 1, 2, 3, 4, 10, 10-hexachloro-1, 4, 4a, 5, 8, 8a-hexahydro-1, 4, 5, 8-endoexo-dimethanonaphthalene. Shell Chemical Corp.
5	Lindane	25% wettable powder. 1, 2, 3, 4, 5, 6-hexachloro-cyclohexane 99% or more gamma isomer. Dow Chemical Co.
6	Endrin	25% wettable powder. 1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4, 5, 8-endo-endo-dimethanonaphthalene. Shell Chemical Corp.
7	Korlan (ET-14)	25% wettable powder. 0-0-dimethyl 0-2, 4, 5-trichlorophenyl phosphorothioate. Dow Chemical Co.
8, 8a	Dipterex	50% wettable powder. Dimethyl (2, 2, 2-trichloro-1-hydroxyethyl) phosphonate. Chemagro Corp.
9	Chlorthion	25% wettable powder. 0, 0-dimethyl 0-(3 chloro-4-nitrophenyl) thiophosphate. Chemagro Corp.
54	RE-4355 (Dibrom 8)	Emulsifiable concentrate. Six pounds per gallon of a "polyhalogenated phosphate compound." California Spray-Chemical Corp.
Fungicides		
21	Omadine disulfide	50% wettable powder 2-pyridinethione 1-oxide disulfide. Olin Mathieson Chemical Corp.
22	Omadine manganese	50% wettable powder. 2-pyridinethione 1-oxide manganese salt. Olin Mathieson Chemical Corp.
23	1563	50% wettable powder. 2-pyridinethione 1-oxide zinc salt. Olin Mathieson Chemical Corp.
24	1564	50% wettable powder. 2-pryidinethione 1-oxide manganese salt. Olin Mathieson Chemical Corp.
25	8599	50% wettable powder. S-trichloromethyl-p-toluenethiosulfonate. American Cyanamid Co.
26	14307	50% wettable powder. S-trichloromethyl-p-chlorobenzenethiosoulfonate. American Cyanamid Co.

Table 1 (Continued)

Treatment number	Name	Composition and manufacturer
27	Mesulfane	50% wettable powder. n-methane-sulfon-N-trichloro-methano-mercapto-4-chloranilide. Geigy Agricultural Chemicals.
28	TB-4452	20% wettable powder. Quinoxime benzoyl hydrazone. Farbenfabriken Bayer. (R. J. Geary & Chemagro in U.S.).
29	CP-6461	75% wettable powder. A "heterocyclic nitrogen containing compound." Monsanto Chemical Co.
30	CP-7403	43.9% wettable powder. p-chlorophenyl trichloro-methyl-disulfide. Monsanto Chemical Co.
31	Ceresan D	2.8% ethyl mercury 2,3 dihydroxy propyl mercaptide plus 0.6% ethyl mercury acetate. (liquid) E. I. duPont deNemours and Co.
32	Ceresan S	6% ethyl mercury 2,3 dihydroxy propyl mercaptide plus 1.3% ethyl mercury acetate. (liquid) E. I. duPont deNemours and Co.
33	Merbam 10	15% wettable powder. phenyl mercury dimethyl dithio-carbamate. Chipman Chemical Co., Inc.
34	Panogen 15	2.2% methyl mercury dicyandiamide. Panogen, Inc.
35	Puraseed	Wettable powder. 6.25% anilinocadmium lactate and 6.5% N-phenyl mercuriformamide. Gallowhur Chemical Corp.
36	Thiram suspension	40% aqueous suspension of thiram. E. I. duPont deNemours and Co.
37	Merculine	10% phenyl mercury salicylate. (liquid) H. L. Woudhuy-sen, Associates.
38	Orthocide 75	75% wettable powder. captan. California Spray-Chemical Corp.
39, 39a	MEMA RM	4.88% methoxy ethyl mercury acetate (liquid). Chipman Chemical Co., Inc.
40	Memasol YF 3576	23.85% wettable powder. methoxy ethyl mercury acetate. Chipman Chemical Co., Inc.
41	Filipin	33 1/3% wettable powder. Filipin antibiotic. The Upjohn Co.
42	Emmi	10% wettable powder. N-ethylmercury-1,2,3,6-tetrahydro-3,5-methano-3,4,5,6,7,7-hexachloro-phthalimide. Velsicol Chemical Corp.
43	Phygon S.P.	50% wettable powder. dichlone. Naugatuck Chemical Co.
44	Arasan SF-X	75% wettable powder. thiram. E. I. duPont deNemours and Co.

Table 1 (Continued)

Treatment number	Name	Composition and manufacturer
45	B-856	50% wettable powder. 1,3-dichloro-5,5-diphenyl hydantoin. Chemagro Corp.
46	B-1843	50% wettable powder. Trans-1,2-Bis(n-propylsulfonyl)-ethylene. Chemagro Corp.
47	C-272	50% wettable powder. Trans-1,2-Bis(ethylsulfonyl)-ethylene. Chemagro Corp.
48	ME 5473	50% wettable powder. N-(2,5-dimethylphenyl) dichloromaleimide or NIA 2282. Niagara Chemical Div. Food Machinery and Chemical Corp.
49	ME 6053	50% wettable powder. p-phenylene diisothiocyanate or NIA 2171. Niagara Chemical Div.
51	G-27810	50% wettable powder. "A material chemically related to mesulfane." Geigy Agricultural Chemicals.
53	RE 4207	75% wettable powder. A "halo nitrogen aromatic compound." California Spray-Chemical Corp.
Insecticide-Fungicide Combinations (Commercial)		
13	HL 807	Wettable powder. 50% captan plus 12.5% dieldrin. California Spray-Chemical Corp.
14	Panoram D-31	Wettable powder. 56.2% thiram, 16% dieldrin. Panogen, Inc.
15	PA-2N	4% methyl mercury dicyandiamide, 24.4% aldrin. (liquid). Panogen, Inc.
16, 16a	Puradrin	Wettable powder. 2.5% phenylamino cadmium dilactate, 2.5% phenyl mercury formamide, 40% aldrin. Gallowhur Chemical Corp.
17	Delsan AD	Wettable powder. 60% thiram, 12.75% dieldrin. E.I. duPont deNemours and Co.
18	Phygon-lindane	Wettable powder. 39.1% dichlone, 16.4% lindane. Naugatuck Chemical Div.
19	Phygon-dieldrin	Wettable powder. 37.8% dichlone, 18.4% dieldrin. Naugatuck Chemical Div.
20	Ortho. Seed Guard	Wettable powder. 50% captan, 16.5% lindane. California Spray-Chemical Corp.
52	HL 891	Wettable powder. 50% captan, 20% RE 4274 (a "halo nitro aromatic compound" fungicide). California Spray-Chemical Corp.

EXPERIMENTAL RESULTS

Field stands of healthy plants for the three trial years, 1956, 1957, and 1958, are presented in Table 2. The 1956 and 1957 trials have also been summarized in annual reports (3, 4).

1956

Thirty-seven of the materials used on peas, 37 on beans, and 40 on cucumbers gave final stands significantly (1 percent level) superior to the controls. The organic fungicide-insecticide combinations gave the most satisfactory stands of peas and beans, followed by the organic fungicides and the organic mercuries. Mercury compounds were best as a class on cucumbers, followed by the organic fungicide-insecticide combinations and the organic fungicides alone. Several insecticides, such as lindane on peas, endrin on cucumbers, and dieldrin, heptachlor, aldrin, and lindane on beans, were injurious. No significant infestation of seed infesting insects was found in any of the plantings of 1956, 1957, or 1958.

Germination of peas in 1956 ranged from 88 to 100 percent with an overall average of 97.9 percent. The range on beans was from 82 to 100 percent and averaged 94.8 percent. Cucumbers germinated from 90 to 100 percent and averaged 98.4 percent. None of the results of the germination tests reflected seed injury that was noted in the field trials.

1957

Thirty-two of the materials used on peas, 35 on beans, and 39 on cucumbers were superior to the control (1 percent level). Under the severe conditions encountered in the field in 1957 most of the mercury materials reduced emergence of peas. Some reduction in field stands apparently was due to length of storage of treated seeds since the downward trend continued into 1958. Puradrin, Ceresan D, Ceresan S, Puraseed, Mema RM, and Memasol YF were among the mercury materials that produced some degree of storage injury to peas. Puradrin, Ceresan D, Mema RM, Memasol YF, and RE 4207 gave similar storage injury on beans. None of the mercury materials, with the possible exception of Mema RM and RE 4207, produced clear evidence of storage injury on cucumber seeds.

The parallel germination test made in 1957 after 1 year of storage gave a range of 96 to 100 percent on peas with an average of 99.3 percent, 76 to 100 percent on beans with an average of 90.1 percent, and 90 to 100 percent on cucumbers with an average of 96.7 percent. None of the reductions in germination corresponded with storage injury to seeds planted in the field.

1958

Growing conditions at East Lansing in 1958 were more favorable for emergence of peas than in 1956 and 1957, as shown by the higher stands in the control plots and insecticide treatments. Storage injury, sufficient to nullify residual benefits of the fungicide in some cases, was caused by the more volatile mercuries. The stands of beans and cucumbers were relatively poor and only a few treatments resulted in stands comparable to the best treatments in 1956 and 1957. Twenty of the materials used on peas, 15 on beans, and 33 on cucumbers were superior to no treatment at the 1 percent level of significance.

When the more effective materials are ranked according to the average stands for all crops and years they appear in the following order of decreasing effectiveness: TB 4452, Orthocide 75, No. 1563 (Omadine zinc), Ortho Seed Guard, HL 807 (captan-dieldrin), Phygon Seed Protectant, Merbam 10, Phygon-lindane, thiram suspension, Puraseed, Delsan AD, B-1843, Phygon-dieldrin, Panoram D-31, Mesulfane, B-856, Dieldrin plus B-856, Arasan SF-X, No. 1564 (Omadine manganese), ME 5473, Ceresan S. The control ranked fortieth of the 54 treatments.

Laboratory germination was still high for all treatments in 1958. No effort was made to correlate germination quality in the laboratory with field stands. It is known, however, that injury may be produced on peas by certain mercurial treatments (5). These seeds may germinate but produce deformities that would result in poor field emergence and stands.

On beans there was a general reduction in field stands resulting from insecticidal treatments over the 3-year period. This reduction was not apparent on peas and cucumbers. Length of storage appeared to have had little effect since initial damage seen in 1956 was not increased by 2 years of storage. One of the insecticides, Chlorthion, appeared to have fungicidal properties when used on cucumber seed, since the stands were consistently above those of the respective controls. In general there was no increase in stands resulting from insecticidal treatments due to the absence of a soil insect infestation.

Table 2. Percent stand of healthy seedlings (1956, 1957, and 1958) of Alderman Peas, Round Pod Kidney wax beans, and National Pickling cucumbers treated in 1956 with various seed protectants.

Material	Ounce formulation per 100 pounds of seed: Peas Beans	Ounce formulation per 100 pounds of seed: Cucumber	Percent field stand: Peas 1956	Peas 1957	Peas 1958	Beans 1956	Beans 1957	Beans 1958	Cucumbers 1956	Cucumbers 1957	Cucumbers 1958	Averages (all plots)
1. Dieldrin 50%	1	2	16.6	5.0	37.7	22.5	11.3	13.0	43.7	41.0	18.4	23.2
2. Dieldrin 24%	2	4	19.8	5.7	32.5	18.8	12.8	16.0	48.7	44.2	9.6	23.1
3. Heptachlor	1	2	17.5	4.3	35.5	19.2	16.5	21.0	53.3	40.5	13.4	24.5
4. Aldrin	2	4	13.5	3.8	29.2	14.0	14.0	19.3	53.0	38.8	11.6	21.9
5. Lindane	2	4	7.7	3.2	33.2	13.8	12.0	20.3	45.8	38.5	10.6	20.5
6. Endrin	2	4	12.2	5.5	23.0	20.5	10.0	15.0	38.0	35.0	12.6	19.0
7. Korlan (ET-14)	2	4	13.3	6.8	30.7	24.2	20.8	25.3	51.7	33.0	13.4	24.3
8. Dipterex	1	2	16.8	11.2	32.5	34.2	36.0	30.5	53.7	33.0	13.4	29.0
8a. Dipterex	2	-	16.6	5.8	13.7	--	--	--	--	--	--	12.0
9. Chlorthion	2	4	11.6	2.7	37.0	37.8	33.7	29.2	79.7	74.8	32.4	37.6
10. Dieldrin 50% + B-856	1 + 2	2 + 4	77.3	31.2	77.5	90.2	85.5	48.2	88.3	63.5	37.4	66.5
11. Dieldrin 50% + 8599	1 + 2	2 + 4	64.7	35.3	44.2	72.0	44.3	20.7	84.2	45.8	13.6	47.2
12. Dieldrin 50% + Omadine disulfide	1 + 2	2 + 4	35.3	28.3	55.7	62.2	41.0	24.2	81.8	54.3	33.6	46.2
13. H. L. 807	3	6	84.0	81.0	44.7	87.3	79.2	69.2	90.7	71.7	48.4	72.9
14. Panoram D-31	3	6	75.3	47.2	72.0	81.0	82.2	55.3	86.7	74.0	41.4	68.3
15. PA-2N	2	4	24.5	5.7	28.0	46.8	47.3	27.8	91.5	77.8	39.0	43.1
16. Puradrin	3	6	60.3	39.2	28.2	75.7	44.2	26.0	86.0	78.7	33.0	52.3
16a. Puradrin	2	--	59.6	21.1	7.9	--	--	--	--	--	--	29.5
17. Delsan AD	3	6	80.5	59.8	80.3	87.3	75.5	46.2	92.8	74.0	40.4	70.7
18. Phygon-lindane	3	6	79.7	60.5	87.5	87.3	76.5	50.5	87.3	72.2	44.6	71.7
19. Phygon-dieldrin	3	6	79.3	72.2	67.7	83.8	77.2	44.0	84.7	68.5	42.6	68.8
20. Ortho Seed Guard	3	6	84.5	84.2	82.2	87.8	80.3	56.0	88.5	70.7	36.6	74.5
21. Omadine-disulfide	2	4	57.8	27.8	66.5	72.5	70.8	20.2	85.3	58.7	30.4	54.4
22. Omadine-Manganese	2	4	70.7	37.0	63.7	75.5	64.3	38.5	90.7	67.3	31.4	59.9
23. 1563	2	4	84.2	74.7	78.2	87.7	81.3	71.2	92.7	72.2	34.6	75.2
24. 1564	2	a	72.5	42.2	78.3	71.8	70.8	48.8	86.0	62.5	28.0	64.0

25. 8599	2	4	66.7	48.2	48.3	80.0	55.2	26.0	79.8	45.8	12.0	51.3
26. 14307	2	4	61.8	27.7	24.5	69.0	38.3	22.8	81.7	50.3	13.0	43.2
27. Mesulfane	2	4	63.5	62.0	65.2	82.0	80.3	68.7	88.2	74.5	27.6	68.0
28. TB-4452	2	4	92.2	86.3	88.2	89.7	84.8	57.8	87.5	83.3	36.6	78.4
29. CP-6461	2	4	57.7	41.3	54.5	70.0	62.0	41.0	80.2	58.2	31.0	55.1
30. CP-7403	2	4	18.3	5.0	16.8	25.3	11.7	10.0	60.2	61.3	35.4	27.1
31. Ceresan D	2	4	76.2	32.5	25.3	78.2	56.5	19.0	92.2	75.5	37.6	54.7
32. Ceresan S	1	2	86.0	36.0	38.7	83.7	75.8	26.0	89.7	79.2	37.4	61.3
33. Merbam 10	2	4	70.8	66.2	75.0	85.5	82.8	63.8	89.5	78.5	39.6	72.4
34. Panogen 15	1	2	19.0	6.7	24.5	48.2	53.7	23.5	93.8	73.7	41.0	42.6
35. Puraseed	2	4	81.3	60.5	56.3	86.8	82.8	54.3	90.8	82.7	42.4	70.8
36. Thiram Suspension	3 1/2	7	74.2	62.2	74.0	85.5	84.0	57.2	88.8	75.7	39.6	71.2
37. Merculine	1	2	61.0	45.8	44.5	70.7	61.5	39.5	90.2	69.3	31.4	57.1
38. Orthocide 75	2	4	85.7	82.5	73.5	85.8	84.5	64.7	90.7	79.3	43.6	76.7
39. MEMA RM	1	2	52.3	5.0	23.5	61.8	53.5	28.0	81.8	53.5	17.0	41.8
39a. MEMA RM	2	--	72.1	16.8	8.7	58.1	62.6	26.8	--	--	--	40.8
40. MEMASOL YF 3576	1/2	1	82.0	16.2	24.0	78.3	53.0	27.8	91.5	73.0	31.6	53.0
41. Filipin	2	4	17.8	5.7	16.0	29.8	26.5	13.2	67.2	53.3	29.6	28.7
42. EMMI	1	2	43.5	13.0	35.2	45.8	35.7	35.7	88.6	77.5	35.0	45.5
43. Phygon S.P.	2	4	83.5	74.2	81.8	82.2	78.8	60.3	91.5	70.2	33.0	72.8
44. Arasan SF-X	2	4	73.0	44.5	73.7	84.2	82.8	40.0	91.2	73.5	27.0	65.5
45. B-856	2	4	80.7	36.3	73.2	88.5	81.3	64.0	88.0	62.7	27.6	66.9
46. B-1843	2	4	87.3	63.8	71.5	82.5	80.7	27.8	90.5	76.8	43.4	69.3
47. C-272	2	4	20.2	6.2	23.7	42.7	21.7	6.7	91.3	75.8	41.4	36.6
48. ME 5473	2	4	71.5	50.5	58.7	81.8	75.0	51.7	88.0	69.3	29.4	63.9
49. ME 6053	2	4	55.7	17.0	37.8	78.3	65.7	16.2	67.3	48.8	28.0	46.0
50. Control (water only)	--	--	19.5	5.7	37.2	42.3	41.7	30.8	55.3	41.5	14.6	32.0
L.S.D. 1% level			11.3	13.4	19.5	9.9	10.99	20.0	15.9	11.2	14.0	
51. G-27810	2	4	--	--	--	80.1	80.8	59.5	See No. 24		a	66.1
52. HL 891	2	4	--	--	--	81.5	84.5	59.2	85.6	72.5	24.6	67.9
53. RE 4207	2	4	--	--	--	43.5	12.3	5.5	74.6	51.8	16.4	34.0
54. RE 4355	2	4	--	--	--	47.6	55.8	16.0	59.3	55.8	9.4	27.1

a G-27810 substituted for 1564 on cucumbers only (4 ounces per 100 pound rate).

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OIDIOPSIS DISEASES OF VEGETABLE AND LEGUME CROPS IN ISRAEL

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Mildew diseases caused by the fungus Oidiopsis taurica Tepper, the conidial stage of Leveillula taurica (Lév.) Arnaud, are of common occurrence in Isarel. Rayss (10, 11) has described the fungus as occurring on about 30 ornamental and wild plants. She has found perithecia of Leveillula on eight of these hosts.

As for vegetable and field crops grown in Israel Reichert (12) has recorded Oidiopsis on eggplant, tomato, and chilli as well as on artichoke, and Chorin (4) on potatoes. Savulescu and Rayss (14) have described the Leveillula stage on artichoke. Occurrence of the Oidiopsis disease on alfalfa and fenugreek has been noted by Palti and Nitzany (9), while Dishon and Netzer (5) have quite recently recorded the disease on onion and carrot.

In the following, we shall review the Oidiopsis diseases so far found on vegetables and legumes in various parts of Israel, noting their seasonal and regional distribution, economic importance, and problems of control.

Apart from the above-mentioned case of the artichoke, no perithecia of Leveillula have been found in Israel on any vegetable or legume crop. We are therefore concerned with the Oidiopsis stage only.

COMMON CHARACTERISTICS OF OIDIOPSIS DISEASES

The Oidiopsis diseases to be dealt with here are those found on tomato, eggplant, chilli, potato, carrot, onion, alfalfa, and fenugreek. The diseases on all these hosts have the following characteristics in common:

1. Symptoms on all hosts, except fenugreek, are limited to the leaves, and neither stalks nor fruits are affected.
2. The symptoms on all hosts except onion consist of yellow spots on the upper leaf surface, with no powdery covering generally apparent on this surface. On the lower leaf surface these spots are covered with a whitish down; here the affected leaf tissue may assume a brownish coloration, especially on chilli and fenugreek.
3. The diseases are never found on young plants. On the solanaceous hosts they may appear 4 to 7 weeks after planting, on the other hosts only during the second half of the vegetative period.
4. The diseases progress from the older to the younger leaves.

OIDIOPSIS DISEASES OF SOLANACEOUS CROPS

Tomatoes

Symptoms: The leaf symptom consists of a bright yellow spot on the upper leaf surface (Fig. 1), pinkish-white, powdery covering on the lower leaf surface. The spots vary greatly in size and coalesce eventually. Affected tissue dries up from the center of the spot outwards. The mildewed leaves dry up completely, but usually do not shed.

Distribution: In the coastal plain, the disease is rarely found on tomatoes before the first half of June, and the spring crop thus escapes infection. On summer and autumn planted tomatoes, the mildew is common in this region, but causes marked losses only in years with particularly warm and dry autumn months.

In the Huleh Valley, the tomato mildew also appears in general only in July. But here the incidence of disease mounts rapidly in the late summer and autumn months, and the disease may be highly destructive. The warm and dry climate of this valley seems to favor development of the disease very markedly.

In the Upper Jordan Valley (just south of the Sea of Galilee) and the Beisan Valley tomato mildew is known as a serious disease. Here tomatoes planted in September-October are severely attacked in the second month after planting. A second, lighter attack often follows in March, when new foliage forms on these plots.

The Oidiopsis disease of tomatoes has been recorded in many Mediterranean and Middle East countries, including Morocco (1), Italy, Iraq, Cyprus, and northern Sudan, as well as in Burma.

The above distribution abroad supports the conclusion formed on the basis of the records made in Israel, that the Oidiopsis disease on tomatoes is favored by, or is actually restricted to, conditions of low humidity.

Control: According to results published by Reichert et al. (13) sulfur dusts and sprays are effective in controlling *Oidiopsis* on tomatoes. These treatments are regularly applied by growers as a means of combining control of this disease with control of tomato rust mite.

Eggplants

Symptoms: The Oidiopsis disease appears on the upper side of eggplant leaves as a faintly yellow spot of varying diameter. On the underside of the leaf this spot is covered by whitish growth (Fig. 3). As on tomatoes, the spots eventually coalesce, the leaves dry up, but do not shed.

Distribution: In the coastal plain, *Oidiopsis* appears on eggplants even later in summer than it does on tomatoes, and is not usually found before July. In late summer and autumn, however, the disease here develops in most years more strongly than on tomatoes, and is often of economic importance.

Summer crops of eggplants in the Huleh Valley and many other parts of the country, and autumn crops grown in the Jordan and Beisan valleys, are also affected by the Oidiopsis disease to an extent necessitating control measures. The disease is thus far less restricted in its distribution than is tomato mildew, and appears under both humid and dry conditions.

The Oidiopsis disease on eggplants is likewise more widely distributed abroad than is the same disease on tomatoes. On eggplants severe losses have been caused in Turkey (3), and *Oidiopsis* has been recorded in Italy, Morocco, Egypt and Syria, Cyprus, Sudan and outside the Mediterranean area in the Ivory Coast, Madagascar, India and Burma.

Control: Growers experience no difficulty in controlling the disease on eggplants by sulfur dusts and sprays.

Chilli

Symptoms: On the upper side of affected leaves appear spots of various shades of yellow (Fig. 2). On the lower side of the leaves these spots appear as brownish discolorations with a somewhat grainy texture, and may or may not be covered with whitish growth. The spots may coalesce, but affected leaves generally shed before this happens. In fact, only slightly affected leaves often show a marked tendency to drop, and severely affected plants may be completely defoliated.

Distribution: The distribution of *Oidiopsis* on chilli much resembles that of the eggplant mildew both in seasonal and regional occurrence, and it likewise does not appear to be restricted to either humid or dry conditions. But the mildew is much more destructive on chilli than on eggplant and may ruin the crop.

Control: Sulfur treatments are effective, but only when well-timed. Once the disease has developed extensively on the lower leaves, it is extremely hard to prevent defoliation. Growers therefore practice preventive treatments for the control of mildew on chilli.

On chilli, extensive leaf drop by *L. taurica* has been reported from Spain and Tunis, the disease is widespread in parts of the Sudan (2), and has further been recorded in Morocco, Turkey, Cyprus, Mozambique, Abyssinia, China, Japan, Java, India and Ceylon. This wide distribution surely indicates that *L. taurica* may thrive on chilli under a variety of conditions, as was also pointed out in 1927 by Schweizer on the basis of his studies in Java.

Potatoes

Symptoms: The symptoms on potato leaves have been fully described by Chorin (4) as follows: "The Oidiopsis disease appears on the underside of leaves in form of greyish covering of the veins. The veins, and sometimes the tissue between them, turn brown, and the spots are dispersed singly over the lower leaf surface. On the upper side appears a yellow spot corresponding with the area covered by the greyish powder on the lower side of the leaf. Finally, the isolated brown spots coalesce, the midrib turns brown; the yellow spot previously apparent on the upper side likewise turns brown and dry, and the entire leaf browns and dries up." To this description we only have to add that affected leaves do not shed. In the field it is not easy to distinguish between the Oidiopsis disease of potatoes and their more common Oidium mildew. The principal difference lies in the fact that the *Oidium* causes the browning

of stalks and covers the leaf blade with a coherent, whitish covering, whereas the Oidiopsis is restricted to the blade and causes isolated spots which only later coalesce.

Distribution: We have so far found the Oidiopsis disease on potatoes only in November and December on autumn sown crops in the Huleh Valley, and Chorin reported its occurrence in the Beisan Valley and at the Dead Sea. This distribution indicates a strong preference for dry conditions. The disease is rare and of no economic importance.

No record of Oidiopsis on potatoes appears to have been published abroad, except from Turkey by Bremer et al. (3).

OIDIOPSIS DISEASES OF OTHER VEGETABLES

Carrots

Symptoms: Isolated yellowish spots appear on the upper leaf surface, with a whitish covering on the lower leaf surface. The spots are sometimes bordered by the veins and are then angular in shape. On carrots, as on potatoes, an Oidium type of powdery mildew is much more common than the Oidiopsis type, and is distinct from the latter by causing at first whitish spots, later coherent whitish coverings on both leaf surfaces and on leaf stalks.

Distribution: Oidiopsis has been found on carrots only in rare instances, in November and January, in the Northern Negev and Beisan Valley, on autumn sown crops nearing maturation.

The only reference to Oidiopsis on carrots that we could find is made by Boughey (2), who states that the disease occurs occasionally in parts of the Sudan. Records of Oidiopsis on other umbelliferous hosts are more numerous: on Foeniculum vulgare (fennel) the mildew has been found in Portugal, France, Cyprus, the Sudan, and Israel (11) on Petroselinum sativum (parsley) in the Sudan (2).

Onion

Symptoms: Dishon and Netzer (5) have described the symptoms of Oidiopsis on onions as follows: "The affected part of the leaf is covered by a fine net of hyphae, white to greyish-white in colour, round but irregular boundaries, up to 1 cm in diameter. Only at a later stage the tissue underneath the fungus turns yellow. The leaves remain upright and succulent, but look pale. The fungus attacks only the older leaves."

Distribution: So far the disease was noted only in 1955 in the western Valley of Jezreel, and in 1957 in the Western Galilee, in both years in October and November. It disappeared later in the season, without necessitating control measures.

As far as we are aware, no reference has been made in literature to the appearance of Oidiopsis mildew on onions. The only record of the mildew on allied crop seems to be that of Boughey (2) on garlic (Allium sativum) in the Sudan.

OIDIOPSIS DISEASES OF LEGUMES

On leguminous crops, Oidiopsis has so far been found in Israel only on alfalfa and fenugreek. The Oidiopsis recorded by Melchers (6) in Egypt on Trifolium alexandrinum has not been found here, nor have we found the disease on the many leguminous hosts on which it has been recorded by Boughey (2) in the Sudan, including Vicia faba, Pisum sativum, Lathyrus sativus, Lupinus termis and Cicer arietinum.

Alfalfa

Symptoms: On the upper leaf surface spots appear which are at first faintly, later brightly, yellow. The spots dry up from their center outwards. The spots are generally elongated, with their base often on the midrib and their sides bordered by secondary veins. On the lower leaf surface the spots may show a white covering while the yellowish discoloration on the upper side is still faint (Fig. 4). Affected leaves dry up but do not generally shed. The lower leaves are always the first to be affected.

Distribution: The disease is found in late summer and autumn in the Huleh Valley, and in early winter in the Jordan and Beisan valleys. It rarely occurs in particularly dry localities in the coastal plain and in the Negev. As the Oidiopsis appears on alfalfa leaves only when these are at least 4 to 5 weeks old and the crop is usually cut at this stage, little damage is

FIGURE 1. Disease symptoms on tomato, showing yellow spots on upper surface of the leaf.

FIGURE 2. Disease symptoms on chilli, showin yellow spots on upper surface of the leaf.

FIGURE 3. Disease symptoms on the under side of an eggplant leaf. Note the whitish growth covering the faintly yellowish spots.

FIGURE 4. Disease symptoms on the under side of alfalfa leaves. The white covering may appear while the yellowish discoloration on upper side is still faint.

caused by the disease.

Oidiopsis on alfalfa has been recorded in the Sudan (15) where it causes appreciable losses, in Turkey (3) and in Cyprus (7) as well as in Central Asia. In Cyprus, perithecia were also found.

Fenugreek (Trigonella foenum-graecum)

Symptoms: A whitish covering appears first on the upper side of the leaves, then on their lower side, and on the stalks and pods. Subsequently, brownish discolorations of the affected tissue are discernible under the whitish covering.

Distribution: The disease occurs in all parts of the country, between February and May-June. Crops are never affected during their first 2 months of growth. The disease therefore causes damage only on seed crops.

Oidiopsis on fenugreek has also been recorded in India and in the Sudan, where it is common (2).

HUMIDITY RELATIONS OF OIDIOPSIS

In its appearance on various host species, the fungus Oidiopsis taurica exhibits wide variations in humidity relationships. Of the crops dealt with here, all have been found affected under dry conditions. But in its attack on tomato, potato and lucerne the fungus in definitely restricted to such dry conditions, whereas chilli pepper and eggplants, and probably also fenugreek, may be affected under both dry and humid conditions. Records on carrots and onion are too few to permit of conclusions in this respect.

Biological data on humidity requirement of O. taurica have been published by Zwirn (16) and recently by Nour (8).

Working with material from 12 hosts, including Capparis, Passiflora, Foeniculum, and Gaillardia (but none of the hosts we have dealt with here) Zwirn concluded that the fungus is markedly xerophytic, the optimum for both production and germination of conidia being represented by relative atmospheric humidities of 52 to 75 percent. On the other hand, Nour found that conidia from Euphorbia heterophylla and Cynara scolymus germinated at extremely wide ranges of humidity, even as low as 0 percent with optimum germination at 75 to 100 percent.

Of the mildews dealt with here, the ones affecting tomato, potato and lucerne show the preference for dry conditions that is consistent with Zwirn's conclusions. However, on chilli and eggplants, the fungus showed no xerophytic behavior, appearing on both under widely varying conditions of humidity; this is in agreement with the results obtained by Nour.

These differential humidity relationships of O. taurica on its various hosts are capable of at least two interpretations:

(a) the existence of biologically distinct strains of the fungus on various hosts.

(b) the prevalence of a single strain which is capable of infecting all hosts at low humidities, but only a limited number of hosts at higher humidities.

In 1955, Ciccarone demonstrated the existence of biometrically and parasitically distinct strains of L. taurica on artichoke, tomato, chilli, eggplant and olive. Zwirn's (16) results point in the same direction. However, Nour (8) succeeded in cross-inoculating four hosts belonging to the genera Gossypium and Euphorbia with conidia from broad bean, but not from Abutilon. He concludes that certain strains of O. taurica are not specialized and capable of infecting various host genera. In view of the numerous weed species affected by this fungus in the Sudan, at all seasons, Nour holds that, in the absence of perithecia, the fungus is perpetuated from year to year by transmission on weeds. This may well be the case in Israel.

SUMMARY AND CONCLUSIONS

Symptoms, distribution and control measures are described of Oidiopsis diseases occurring in Israel on tomato, eggplant, chilli, potato, carrot, onion, alfalfa and fenugreek. No perithecia have been found on any of these crops.

The symptoms are not found on young plants, and progress from older to younger leaves; they usually consist of yellow spots on the upper leaf surface and whitish down on the lower leaf surface.

Apprectable losses are caused by Oidiopsis on tomato, eggplant, and chilli only. On potato, carrot, and onion the disease is rare, on alfalfa and fenugreek it usually appears too late to cause damage.

The above Oidiopsis diseases differ widely among themselves in their seasonal and regional distribution in Israel. As far as can be concluded from the relatively scare literature references this also seems to apply to their distribution abroad.

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TEL-AVIV, ISRAEL

RELATIONSHIP OF NEMATODES TO SMALL GRAINS AND NATIVE GRASSES IN NORTH AND CENTRAL TEXAS[1]

Don C. Norton

Abstract

During an investigation of the role of nematodes in the dry land foot rot of wheat in North and Central Texas, 1356 samples were taken from around roots of small grains and native grasses. Tylenchorhynchus acutus was the most common nematode studied and appeared not to be restricted by host plant, soil texture, or land resource area. Helicotylenchus nannus, Paratylenchus projectus, Rotylenchus robustus, Tylenchorhynchus brevidens and Xiphinema americanum were more common in some land resource areas than in others. Some nematodes appeared to be more prevalent in the heavier than in the lighter soils.

Distribution and pathogenicity studies in the field and greenhouse indicate that most nematodes are not contributing seriously to the poor yields of wheat in North Texas.

Much of the reduction in yield of small grains in some areas of North Texas, especially the Rolling Plains, has been attributed to root rotting fungi. Although no conclusive study of the problem has been made, Helminthosporium sorokinianum Sacc. ex Sorokin and various species of Fusarium are suspected of causing at least part of the damage. Hsi (6, 7) isolated H. sorokinianum, Pellicularia filamentosa (Pat.) Rogers, and species of Curvularia and Fusarium from roots of small grains in three New Mexico counties adjacent to the Texas Panhandle. Nematodes as a possible factor in causing at least part of the reduction in small grain yields has never been investigated in Texas. Although many nematodes are known to be associated with the roots of small grains, there are only a few proven instances where they cause damage. Benedict and Mountain (1) found that Pratylenchus minyus Sher and Allen, 1953 caused a reduction of wheat growth in Ontario. Oostenbrink et al. (8) believe that both Pratylenchus pratensis (de Man, 1880) Filipjev, 1936 and Paratylenchus sp. caused a reduction of rye growth in the Netherlands. Coursen and Jenkins (3) recently reported Paratylenchus projectus Jenkins, 1956 to cause a slight stunting to tall fescue. Heterodera major (O. Schmidt, 1930) Franklin, 1940 is distributed widely in Europe and often is destructive (4). Heterodera punctata Thorne, 1928 occurs in England (4) on the grasses Agrostis stolonifera L. and A. tenuis Sibth. and on wheat in Saskatchewan (10) and in Minnesota and North Dakota (9).

As an initial step in a study of nematodes associated with root rots of small grains in North Texas, a survey for plant parasitic species was initiated in 1954 and terminated in 1957. Fifty-six samples from Curry and Roosevelt Counties in eastern New Mexico are included in the High Plains region. Data were recorded primarily on seven species: Helicotylenchus nannus Steiner, 1945 Paratylenchus projectus, Pratylenchus hexincisus Taylor and Jenkins, 1957, Rotylenchus robustus (de Man, 1876) Filipjev, 1936 Tylenchorhynchus acutus Allen, 1955 Tylenchorhynchus brevidens Allen, 1955 and Xiphinema americanum Cobb, 1913.

The regions in which samples were taken are outlined in Figure 1.

SURVEY PROCEDURE

All grain-producing areas were surveyed regardless of whether any particular trouble was known. The regions of concentrated grain production were surveyed most. Native grasses were sampled, in many cases, for comparison purposes. Surveying was conducted mostly in April, May or June as the crops were heading or maturing. Composite samples were made by mixing about 1 pint of soil taken from around the roots of several plants. In large fields, several additional samples were taken throughout the field. Except for nematode population and

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FIGURE 1. Location of the four major land resource areas in Texas surveyed for nematodes in association with small grains and grasses.

pathogenicity studies over the growing season, when soil was processed the day following sampling, the storage time between sampling and processing usually did not exceed 10 days. Soil was processed by a slight modification of Christie and Perry's (2) method. In the latter part of the investigations, soil texture was determined for all samples.

SURVEY RESULTS

Data on nematode species and host plant association were kept for 1356 samples. Information for the seven nematode species studied is presented in Table 1. *Tylenchorhynchus acutus* appears to be associated widely with grains and grasses while *T. brevidens* is more restricted. *Helicotylenchus nannus* and *Xiphinema americanum* are more commonly associated with native grasses than with cultivated grains. *Rotylenchus robustus* was common around some of the native grasses but was never found associated with small grains.

Information was kept for soil texture on 681 wheat samples. This information for the four land resource areas is presented in Table 2, and for soil texture in Table 3. The data reveal that some nematodes are associated more commonly with wheat in some areas of the State than in others. In many cases, sufficient samples were not taken to justify any positive statements regarding the role of soil texture in their distribution. Some trends do seem worthy of mention. *Tylenchorhynchus acutus* appears to be common in many different soil textures. In the

Table 1. Association of seven species of nematodes with various grains and grasses in North and Central Texas.

Scientific name	Common name	Total plants sampled	Percent nematode occurrence of plant sampled						
			Helicotylenchus nannus	*Paratylenchus projectus*	*Pratylenchus hexincisus*	*Rotylenchus robustus*	*Tylenchorhynchus acutus*	*Tylenchorhynchus brevidens*	*Xiphinema americanum*
Triticum aestivum L.	Wheat	989	0.4	12.8	11.3	0.0	17.4	20.4	3.1
Avena sativa L.	Cats	159	6.7	2.5	2.5	0.0	30.3	25.2	10.1
Andropogon saccharoides Swartz *var. saccharoides*	Silver bluestem	41	45.2	9.7	9.7	29.0	48.4	0.0	25.8
Andropogon scoparius Michx.	Little bluestem	32	19.2	31.2	3.1	25.0	31.2	0.0	28.1
Hordeum vulgare L.	Barley	30	0.0	13.3	10.0	0.0	26.6	16.7	3.3
Sorghum halepense (L.) Pers.	Johnsongrass	15	20.0	0.0	20.0	13.3	60.0	0.0	33.3
Andropogon gerardi Vitman	Big bluestem	13	0.0	0.0	0.0	0.0	40.0	0.0	8.0
Elymus virginicus L.	Virginia wild-rye	13	8.0	0.0	0.0	53.9	23.1	46.2	0.0
Elymus canadensis L.	Canada wild-rye	11	.1	0.0	7.1	36.4	72.7	36.4	55.5
Andropogon ischaemum L.		8	75.0	0.0	12.5	0.0	0.0	12.5	12.5
Bouteloua curtipendula (Michx.) Torr.	Sideoats grama	8	27.5	12.5	0.0	25.0	37.5	0.0	25.0
Boutelua hirsuta Lag.	Hairy grama	5	60.0	0.0	0.0	0.0	0.0	0.0	0.0
Panicum fasciculatum Swartz	Browntop Panicum	5	60.0	0.0	20.0	0.0	80.0	0.0	0.0
Bromus catharticus Vahl.	Rescuegrass	5	0.0	0.0	20.0	0.0	80.0	60.0	0.0
Aristida purpurea Nutt.	Purple threeawn	4	75.0	0.0	25.0	25.0	25.0	0.0	25.0
Secale cereale L.	Rye	4	0.0	0.0	50.0	0.0	50.0	0.0	0.0
Aristida oligantha Michx.	Prairie threeawn	3	66.7	0.0	0.0	33.3	66.7	0.0	0.0
Digitaria sanguinalis L.	Crabgrass	3	0.0	0.0	66.7	0.0	100.0	0.0	0.0
Paspalum dilatatum Poir.	Dallisgrass	3	100.0	0.0	0.0	0.0	66.7	0.0	0.0
Tridens albescens (Vasey) Woot and Standl.	White tridens	3	66.7	0.0	0.0	0.0	0.0	0.0	0.0
Andropogon sp.		2	100.0	0.0	0.0	0.0	0.0	0.0	0.0
		1,356							

Table 2. Percent of selected nematodes associated with wheat in Central and North Texas.

Nematodes	High Plains	Rolling Plains	Grand Prairie	Blackland Prairies
Helicotylenchus nannus	0.8	0.0	3.3	5.3
Paratylenchus projectus	0.8	15.1	3.3	0.0
Pratylenchus hexincisus	16.4	8.9	3.3	17.3
Tylenchorhynchus acutus	30.4	15.1	13.3	16.0
Tylenchorhynchus brevidens	2.3	25.2	60.0	13.3
Xiphinema americanum	1.5	3.7	10.0	18.6
Total samples taken	128	448	30	75

Rolling Plains, P. hexincisus and T. brevidens were more common in the heavier than in the lighter soils. In some instances, two species occurred in about equal frequencies in the same soil texture of one region but not in another. Some examples are with T. brevidens and X. americanum in clay loam soils of the Rolling Plains and Blackland Prairies.

POPULATION STUDIES WITH PARATYLENCHUS PROJECTUS AND TYLENCHORHYNCHUS BREVIDENS

Abundant populations of P. projectus and T. brevidens, especially in the area of reported root rot trouble, caused interest to be focused on these. Aphelenchus avenae, Dorylaimus spp., members of the genera Tylenchus, Psilenchus and others also were present but in fewer numbers.

Population trends of P. projectus and T. brevidens were studied in field plots 100 x 32 feet divided into 12 equal-sized smaller plots. Each was planted to Wichita wheat and samples were taken at intervals throughout the growing season. A composite sample, consisting of about 1 pint of soil taken from around the roots of eight randomly selected plants, was procured from each small plot. The results presented are the average of 12 such plots. The population was correlated with rainfall records obtained from the Chillicothe, Texas Agricultural Experiment Station about 100 yards distant.

The population fluctuation of P. projectus, T. brevidens and A. avenae during 1955-56 was in general correlated with rainfall (Fig. 2). In general, the season was dry although about 7 inches of rain fell just prior to planting. Following a low population in mid-April, the numbers increased markedly at the May 4 sampling which was 2 days after the heaviest rain of the season. Nearly all individuals were juveniles which probably hatched from eggs present in the soil during the preceding dry period.

The buildup of P. projectus, T. brevidens, A. avenae and Dorylaimus spp. was followed in the greenhouse for 3 months. Infested field soil was mixed thoroughly, a population count taken, and then divided into three lots. One was placed in 2-gallon crocks with no amendment and left unplanted. The second lot was placed in crocks and planted to wheat. To the third was added an abundant supply of sterilized wheat straw and roots cut in 1 to 2-inch sections, placed in crocks and left unplanted. The crocks were kept moist on the greenhouse bench for 3 months. Each month the soil from two crocks of each treatment was removed and sampled for nematodes. In crocks where wheat was planted the samples were taken from the root zone. The results are recorded in Figure 3. P. projectus and T. brevidens both increased readily on wheat, while the others apparently lacked that ability. Conversely, P. projectus and T. brevidens were incapable of increasing on dead organic matter while A. avenae and Dorylaimus spp. multiplied considerably.

Table 3. Percent of selected nematodes associated with wheat in North and Central Texas by soil texture.[a, b]

Nematode	High Plains					Rolling Plains						Grand Prairie		Blackland Prairie[c]	
	SL	SCL	L	CL	C	S	SL	SCL	L	CL	C	SL	C	CL	C
Helicotylenchus nannus	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	7.7	4.6
Paratylenchus projectus	0.0	0.0	0.0	1.8	0.0	2.1	11.2	20.5	0.0	18.8	15.0	0.0	4.1	0.0	0.0
Pratylenchus hexincisus	8.6	13.5	22.2	26.4	0.0	2.1	1.4	0.0	11.1	12.3	15.0	0.0	4.1	23.0	16.1
Tylenchorhynchus acutus	13.0	16.2	44.4	45.2	33.3	31.9	12.6	2.9	11.1	13.2	20.7	50.0	8.3	30.7	12.9
Tylenchorhynchus brevidens	0.0	5.4	0.0	1.8	0.0	8.5	9.8	20.5	0.0	28.2	54.7	25.0	70.8	38.4	8.0
Xiphinema americanum	0.0	0.0	0.0	3.7	0.0	8.5	3.4	0.0	0.0	3.4	9.4	0.0	12.3	23.0	17.7
Total samples taken	23	37	9	53	6	47	71	34	9	234	53	4	26	13	62

[a]S=sand, SL=sandy loam, SCL=sandy clay loam, L=loam, CL=clay loam, C=clay.
[b]absence of a soil texture indicates no samples taken.
[c]the Blackland Prairie consists mostly of heavy soils.

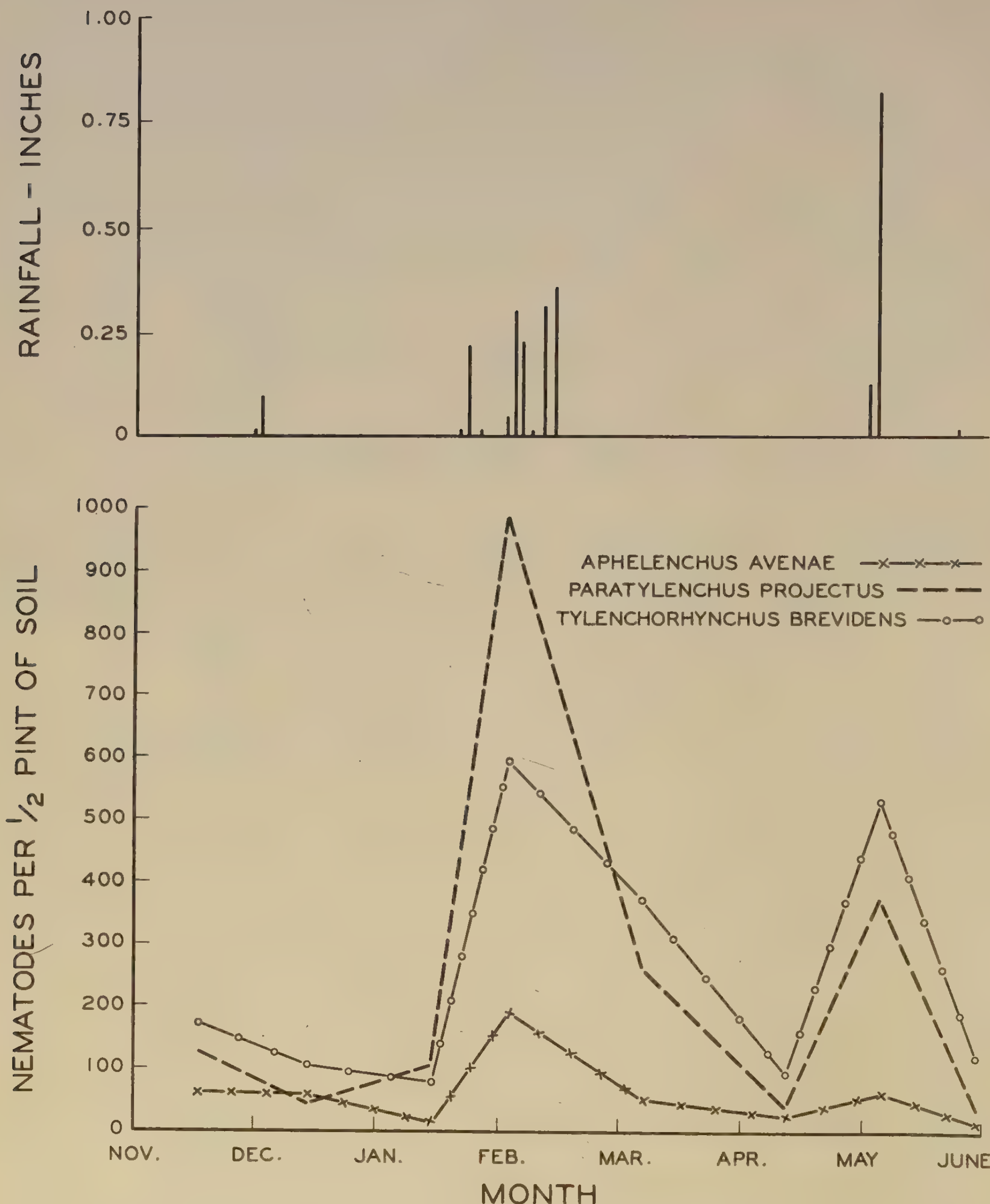

FIGURE 2. Correlation with rainfall of population fluctuation of Paratylenchus projectus, Tylenchorhynchus brevidens and Aphelenchus avenae associated with wheat roots, Chillicothe, Texas, 1955-56.

PATHOGENICITY STUDIES

Small plot field fumigation studies were carried out over a 2-year period in Abilene fine sandy loam soil heavily infested with P. projectus and T. brevidens. A very light infestation of P. hexincisus was also present but did not increase over the growing season. Fumigants were applied at a depth of 8 inches at 1-foot centers with a Mac Lean Fumigun. The plots were seeded 2 weeks after fumigation. Each treatment consisted of three replications of four rows 30 feet long. Only the center 24 feet of the center two rows of each treatment were harvested. Results were largely negative and data for the 1956-57 season are presented in Table 4.

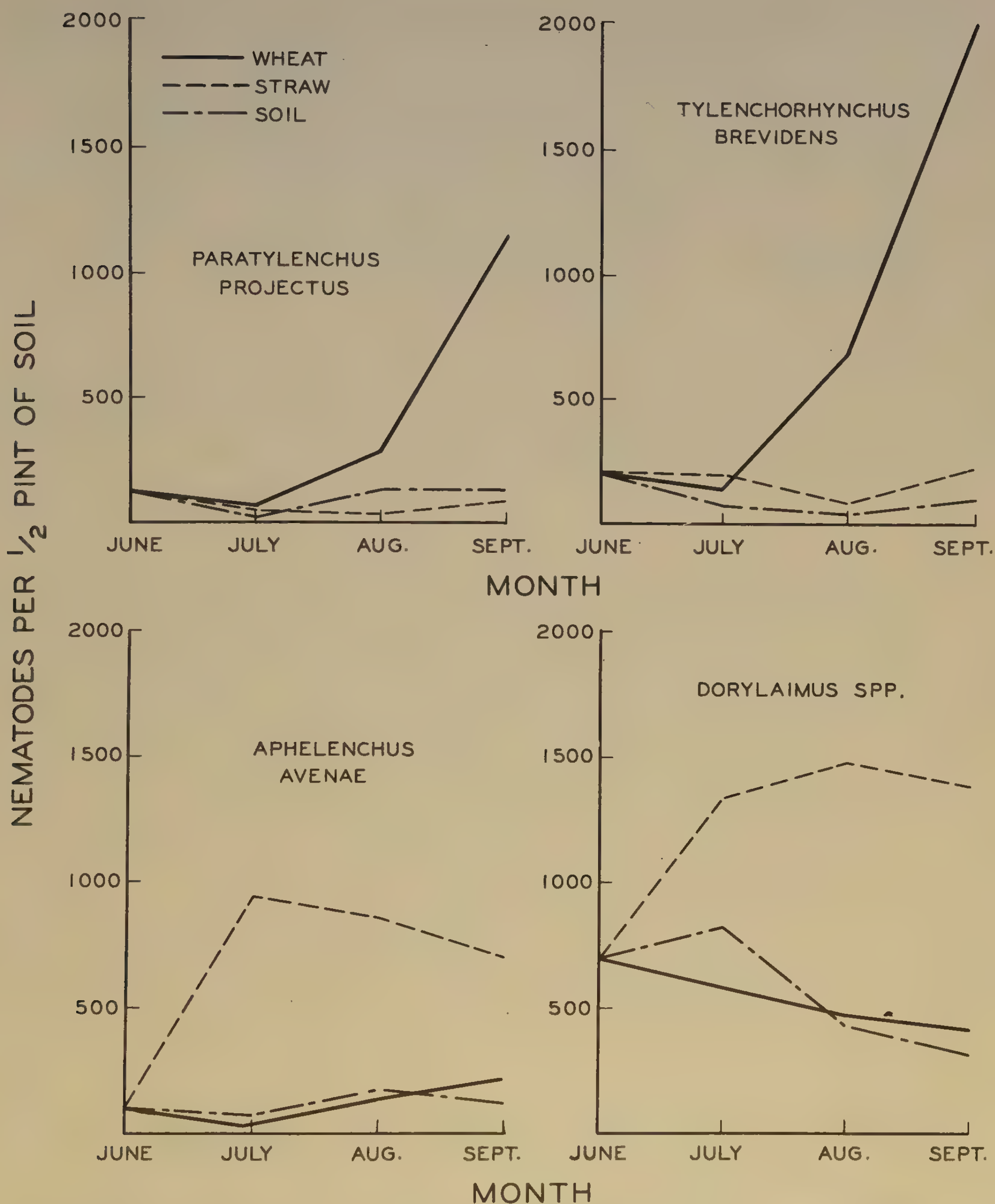

FIGURE 3. Population fluctuation of selected nematodes associated with wheat roots, wheat straw and fallow soil in the greenhouse.

Table 4. Yield of Wichita wheat in fumigation plots on land infested with Tylenchorhynchus brevidens and Paratylenchus projectus, Chillicothe, Texas, 1956-57.

Treatment	Rate of application	Yield (bushels /acre)	Nematodes/1/2 pint soil at harvest	
			T. brevidens:	P. projectus
Methyl bromide	2 pounds/120 square feet	17.8	10	0
Ethylene dibromide	7.5 gallons/acre	16.8	0	0
1-2-dibromo-3-chloropropane	2.3 gallons/acre	14.2	40	0
Check	--------	15.9	2890	990

Even though good control of the nematodes was obtained, no significant increase in yield resulted. Helminthosporium sorokinianum was present in all plots at the conclusion of the experiment. Similar tests with the same three nematodes in the greenhouse likewise were negative.

DISCUSSION

Although Oostenbrink et al. (8) attributed rye damage to a species of Paratylenchus and Coursen and Jenkins (3) noted a slight stunting and increased root proliferation of tall fescue with P. projectus, fumigation tests indicate that this species and Tylenchorhynchus brevidens are not causing economic loss to wheat in the field when associated with other microorganisms. Pratylenchus hexincisus was scattered and populations, on the whole, were low. Helicotylenchus nannus, Rotylenchus robustus and Xiphinema americanum, besides being found in low numbers, were not common in the area of greatest root rot damage and consequently are eliminated as serious factors in the problem. Tylenchorhynchus acutus was common and often in high populations in both healthy and diseased wheat. No inference is made that these or other nematodes could not cause damage to wheat under certain conditions, but field observations and experimental evidence suggest that under common field conditions nematodes are not a serious factor in the wheat root rot problem in Texas.

The more prevalent distribution of some species by land resource area rather than by soil texture may be due, at least in part, to a different geologic derivation of the soils, past natural vegetation, cropping practices or climate. Climate probably has some bearing on the generally low populations obtained in the High Plains where rainfall is about 20 inches per year (5) and precipitation-evaporation ratios are among the lowest in the State. The resulting drought condition would provide little chance for continued nematode buildup.

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OCCURRENCE OF PLANT PARASITIC NEMATODES IN GEORGIA TURF NURSERIES[1]

J. M. Good, A. E. Steele, and T. J. Ratcliffe[2]

Summary

In a survey of Georgia turf nurseries five genera of plant parasitic nematodes were found in 25 to 53 percent of 387 samples of Bermuda, Zoysia, Centipede and St. Augustine grasses. Four other genera were found in from 5 to 17 percent of all samples examined. Certain species occurred throughout the State on all grasses, while others were predominantly found in areas corresponding to the natural soil provinces of Georgia.

In recent years plant parasitic nematodes have been recognized as important pests of turf grasses in several areas of the United States and have been considered responsible for considerable turf injury, damage being reported to golf course greens, home lawns, and turf nurseries. Kelsheimer and Overmann (5) were among the first to attribute turf decline to plant nematodes. In the Tampa Bay area of Florida they reported Belonolaimus gracilis, Trichodorus sp., Criconemoides spp., Hoplolaimus coronatus, Ditylenchus dipsaci, and Radopholus similis associated with root injury and turf decline of St. Augustine grass. A stubby-root condition, similar to that produced on other plants, was attributed to injury caused by the stubby-root and sting nematodes. Working with turf samples from widely scattered locations in Florida, Christie, Good, and Nutter (1) and Good, Christie, and Nutter (3) expanded the list of nematodes attacking turf to include species of Rotylenchus, Xiphinema, Dolichodorus, Pratylenchus, and Hemicycliophora. In addition to St. Augustine grass they found that Bermuda, Zoysia, and Centipede grasses were badly injured by one or more species of nematodes. Lance, sting, spiral, and occasionally stubby-root nematodes were responsible for most of the injury to Florida grasses. From Rhode Island, Tarjan and Ferguson (8) and Tarjan and Hart (9) associated species of Panagrolaimus and Eucephalobus with a yellow turf condition of bentgrass. Additional surveys of golf course greens by Troll and Tarjan (10) indicated that Tylenchorhynchus claytoni and Rotylenchus erythrinae were the most common parasites associated with decline of turf in Rhode Island and, in addition, they found a number of heretofore unreported nematode parasites of grasses. Parris (6) reported species of Tylenchorhynchus, Rotylenchus, Trichodorus, Criconemoides, Xiphinema, Pratylenchus, Hoplolaimus, and Paratylenchus attacking lawn grasses in Mississippi. Jenkins et al. (4) have also reported a wide variety of parasitic and non-parasitic nematodes associated with grasses in Maryland. More recently, Perry (7) found that decline and root injury of Kentucky blue grass in central and southern Wisconsin was caused by Helicotylenchus spp. He established the pathogenicity of these nematodes on blue grass by greenhouse inoculation experiments, field control experiments, and histopathological studies.

During 1956 and 1957 turf nurseries in Georgia were surveyed to determine the distribution and prevalence of parasitic nematodes. Three hundred eighty seven samples were taken from 65 locations in 28 counties of Georgia, representing 34 locations from 13 counties of the Piedmont and Intermountain Provinces, 2 locations from 2 counties of the Upper Coastal Plain, and 15 locations from 5 counties of the Middle Coastal Plain, and 14 locations from 8 counties of the Lower Coastal Plain. Included in the survey were varieties of Bermuda grass (Cynodon dactylon); Myer Zoysia grass (Zoysia japonica); Emerald Zoysia grass (Z. tenuis x Z. matrella); Centipede grass (Eremochloa ophiuroides) and St. Augustine grass (Stenotaphrum secundatum). There were also samples of Bermuda and Zoysia grasses which were not identified as to variety.

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Table 1. Incidence of plant nematodes in 150-gram soil samples from Georgia turf nurseries.

Grass species or variety	Number of samples examined	Percent of 387 samples with plant parasitic nematodes (first figures) and percent with more than 50 nematodes (figures in parentheses).								
		Trichodorus spp.	Xiphinema americanum	Helicotylenchus spp.	Pratylenchus spp.	Criconemoides spp.	Tylenchorhynchus spp.	Belonolaimus spp.	Hoplolaimus tylenchiformis	Tylenchus spp.
Bermuda grass (Cynodon dactylon)										
Tiffine	27	63(11)	41(19)	33(7)	37(4)	41(0)	11(4)	0(0)	19(0)	19(15)
Tifgreen	24	50(17)	25(4)	50(21)	8(0)	21(4)	8(8)	0(0)	21(0)	17(13)
Tiflawn	19	69(11)	37(5)	21(0)	27(5)	21(5)	5(0)	11(0)	0(0)	0(0)
unknown varieties	50	41(7)	16(12)	32(16)	18(4)	22(2)	8(6)	8(4)	12(6)	8(0)
Zoysia grass										
Emerald (Z. tenuis x Z. matrella	62	51(7)	31(5)	24(5)	18(3)	31(2)	29(6)	7(0)	7(2)	18(3)
Myer (Z. japonica)	59	62(14)	59(19)	21(10)	41(7)	23(3)	36(17)	5(2)	0(0)	0(0)
Zoysia matrella	20	55(50)	31(10)	20(5)	20(5)	30(5)	15(5)	10(10)	0(0)	20(10)
unknown varieties	18	66(22)	67(23)	39(11)	28(6)	13(6)	34(17)	0(0)	17(6)	18(12)
Centipede grass (Eremochloa ophiuroides)	46	58(4)	53(27)	24(12)	48(11)	17(0)	4(0)	9(2)	15(2)	6(4)
St. Augustine Grass (Stenotaphrum secundatum)	62	30(7)	13(0)	20(5)	20(10)	19(3)	18(5)	1(0)	5(2)	33(7)
All grasses	387	53(11)	35(12)	27(10)	25(4)	27(3)	17(7)	5(2)	9(3)	14(5)

Soil samples from established turf were taken during the warmer months when grass was actively growing and when soil moisture was adequate for plant growth and nematode reproduction. Soil samples of 150 cc were processed by the modified Baermann technique developed by Christie and Perry (2) and the parasitic nematodes recovered were counted.

A summary of the survey data appears in Table 1. The percent of the total number of grass samples infested with a given nematode is given, as well as the percentage of samples from which more than 50 nematodes were recovered.

At least one species of plant parasitic nematodes was found in all samples examined, and most samples had several species belonging to different genera.

With the exceptions of sting and dagger nematodes and *Tylenchus* species, all the other genera of nematodes were found in from 5 to 67 percent of the samples of all grass species and varieties examined.

About 53 percent of the samples contained stubby-root nematodes, *Trichodorus christiei* Allen, 1957, being the most common species. Dagger nematodes were found in 35 percent of the samples, spiral nematodes in 27 percent, and root-lesion nematodes in 25 percent, the most common species being *Xiphinema americanum* Cobb, 1913, *Helicotylenchus nannus* Steiner, 1945, and *Pratylenchus brachyurus* (Godfrey, 1929) Filipjev and Schuurmans-Stekhoven, 1941, respectively. Stylet nematodes, *Tylenchorhynchus claytoni* Steiner, 1937, and *T. martini* Fielding, 1956, were found in 17 percent of the samples, the former being most common. *Tylenchus* species were found in 14 percent of the samples. Sting nematodes (*Belonolaimus*) were found in only 5 percent of all the samples but in all of the 10 samples of *Zoysia matrella*. Since this genus is being revised, the species were not identified. Lance nematodes (*Hoplolaimus tylenchiformis* Daday, 1905) were found in 9 percent of the samples. Ring nematodes (*Criconemoides* spp.) occurred in 27 percent of the samples, but seldom in large numbers.

Species of *Aphelenchus*, *Aphelenchoides*, *Paraphelenchus*, *Paratylenchus*, *Ditylenchus*, and miscellaneous *Dorylaimidae* and *Neotylenchidae* occurred occasionally in samples from scattered locations. Although root-knot nematodes (*Meloidogyne* spp.) are common in Georgia, *Meloidogyne* larvae were found only rarely in the survey and never in large numbers.

Dagger, ring, stubby-root and stylet nematodes were common throughout the State. Spiral and root-lesion nematodes were found in the largest numbers in the middle and upper Coastal Plain and the Piedmont. Lance and sting nematodes were found mostly on the lower Coastal Plain.

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CONTROL OF THE POTATO ROT NEMATODE IN WISCONSIN

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Summary

Discovery of the potato rot nematode, Ditylenchus destructor Thorne, in Wisconsin late in 1953 led to control studies in 1954. Several different chemicals were tried, of which ethylene dibromide gave the most promising results. Split plow sole applications of this chemical at a total rate of 6 gallons an acre (four on the first and two on the second) were made in the spring and fall. Not a single infested tuber was found on approximately 30 acres treated in this manner either during harvest or after the crop had been in storage for 4 to 6 months. One heavily infested 24-acre field and one lightly infested 4-acre field, replanted a second season without added treatment, also produced a crop of clean tubers.

An infestation of the potato rot nematode, Ditylenchus destructor Thorne, 1945, was discovered in Wisconsin in October, 1953 (5). Two other infestations are known to be present in the United States and Canada, one in Idaho (3) and one in Prince Edward Island, Canada (1), reported in 1943 and 1946, respectively. However, this pest has been reported from several European countries.

In Wisconsin the damage caused by this nematode ranges from an occasional tuber to total loss of the crop in localized areas of a field; the average loss, however, is quite low. Symptoms are confined to the tuber, are similar to those described by Thorne (7) and may appear as early as the first week of August. At this stage external symptoms are rare and evidence of infection can be obtained only by removing a thin surface peeling to reveal small, roundish, somewhat gray to white chalky spots having a granular texture. Examination of such tissue under a dissecting microscope usually reveals the presence of but few nematodes. By late August or early September the symptoms may be characterized by small, dark discolored spots on the surface of the tuber. Removal of a thin peel from a suspected area reveals typical chalky-white granular spots or areas in the tissue and some evidence of decay. Secondary fungi and bacteria are usually present in abundance in advanced lesions along with all developing stages, including eggs, of both male and female nematodes confined mostly to areas where fungi are actively growing. Various stages of dry rot and wet breakdown, as well as tuber cracking, are usually present at harvest in localized areas or spots in a field. These rots closely resemble several types of breakdown commonly found in stored potatoes and associated with mechanical or other injury.

Rigid quarantine measures for this pest are set up and enforced by the Wisconsin State Department of Agriculture. One of the restrictions prohibits the production of potatoes on infested land. Control studies were, therefore, initiated in an attempt to find a nematocide suitable for use under Wisconsin conditions.

MATERIALS AND METHODS

Specimens from all known infested fields were identified by Mr. G. Thorne of the USDA Section of Nematology. Heavily infested land was selected for plot work in the spring of 1954 based on the severity of the infestation the previous season. Four nematocides were selected for preliminary trial[2]:

1. Dowfume W-85. 1,2-dibromoethane. Dow Chemical Company.
2. O-2,4-dichlorophenyl O-O-diethyl phosphorothioate VC-13. Experimental nematocide of Virginia--Carolina Chemical Corporation.
3. Nemagon 1,2-dibromo-3-chloropropane. Shell Chemical Corporation.

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[2]The author wishes to thank the manufacturers for supplying the nematocides gratis.

4. D-D soil fumigant. 1,3-dichloropropene, 1,2-dichloropropane. Shell Chemical Corporation.

All materials were applied as liquids using tractor-mounted weed spraying equipment consisting basically of a gear pump, pressure regulator, flow regulators, tank, suction hose and enough leads arranged to deliver the material to the plow sole or to the rear of chisel teeth. Spray nozzles were used to apply a band of material about 8 inches wide on the plow sole. The machine was operated at about 40 pounds pressure at a tractor speed of 3 miles per hour. The gallonage was calibrated mainly by the disc size used in the flow regulators. To seal the land quickly, an 8-foot spike tooth drag was attached to the plow in an offset postition so that during application the drag would overlap the two previously treated furrows, thus actually dragging the treated areas three times. A jointer attachment for the plow colter was set ahead of each plow for the second plow application and served to turn 2 to 3 inches of the surface soil into the furrow where it could be reached by the fumigant.

Prior to treatment the soil was well worked to eliminate coarse debris and chunks of soil. The materials were applied at an 8-inch depth when the soil temperature at this depth was above 50° F, but did not exceed 80°, and when soil moisture was high or comparable to that of a good seedbed condition for planting potatoes. Treatments were applied while plowing in one direction, but on large plots the second application was made while plowing at a right angle to the original direction. The materials and many of the methods originally used were suggested by Mr. G. Thorne and were based on his experience in Idaho (unpublished results). In 1955, Dallimore (4) reported on methods of increasing the efficacy of soil fumigation in experimental fields infested with this same pest.

Measured yields were taken at harvest and the tubers examined with a common household vegetable peeler. Suspected specimens were taken to the laboratory for further examination under a dissecting microscope. Random samples were also collected from each plot and placed in storage for subsequent examination and analyses.

RESULTS

Heavily infested land was selected on which four nematocides were applied (1954) in individual four-row plots, 12 feet by 110 feet. Two center rows were used for records in each of four replicates and standard production practices were followed throughout the season. Split applications combining a chisel and plow and the plow alone were started May 22 and completed about 12 to 14 days later and planting was completed June 20.

Observations during the summer indicated varying degrees of toxicity in all treatments; compared to the nontreated check, differences in vine growth amounted to as much as 12 inches by midseason. These differences were also reflected in yields that ranged from a high of 285 bushels an acre for the check to as low as 20 bushels in one treatment given an excessive dosage.

Critical examination of each plot at harvest revealed that wherever W-85 was used not a single infected tuber was found. Varying numbers of infected tubers were found in each treatment involving the three other nematocides. The number of infected tubers found in the check plot ranged from one tuber in one replicate to 86 in another, indicating considerable variation in the uniformity of the infestation throughout the plot. Similar results were obtained from random samples taken from each replicate at harvest and examined in late December after storage at 60° to 65° F.

Without further treatment the entire plot was replanted in 1955 and 1956. The data collected in 1955, the second season after treatment, indicated no residual toxic effects to the vines and yields of all treatments were not significantly different from the check. However, single infected tubers were found in two of the replicates of the EDB treatments that had a clean reading the previous year. In 1956 the infestation throughout the plot was considerably reduced, but it is of interest that a heavy infestation in one replicate of the check plot persisted for a period of 4 years under continuous potato culture. It is of added interest that not a single specimen of the potato rot nematode was recovered from soil samples taken to a depth of 10 inches from heavily infested land. Similar results have been obtained from other heavily infested areas in other years.

The data obtained in 1954 indicated that EDB was the most promising nematocide but that yields were considerably reduced following spring treatment. Therefore, two heavily infested 3-acre fields were selected on which split plow sole applications were made in early June and in the fall in late August. A heavily infested field of 24 acres and a 4-acre field with a light infestation were also selected for fall treatment. The soil was characteristic of Antigo silt

loam and contained areas thick with cobblestone. W-85 (EDB) was applied in the fall of 1955 and potatoes were planted in the spring of 1956. Examination at harvest did not reveal a single infected tuber in more than 30 acres treated nor were any infected tubers subsequently found after a storage period ranging from 4 to 6 months. As a further check on this treatment the 24- and 4-acre fields and one small experimental plot were replanted without additional treatment in 1957. The results were identical with those of 1956 in that not a single infected tuber was found in the treated areas either at harvest or after a 4- to 6-month storage period. It is of interest that a very heavy infestation was present in one check plot contiguous to a fall split plow sole treatment. The incidence of infection dropped from 100 percent of the tubers affected in the nontreated to none in the treated at the exact point in the row where the treatment had been applied. This same difference was again quite obvious when the same area was replanted the second season after treatment.

To determine if a lower gallonage of EDB could be used, different rates of 4, 5 and 6 gallons an acre of EDB were applied (split plow) in the fall of 1955. Potatoes were planted in the spring of 1956. At harvest no infected tubers were found in the 6-gallon rate, five were found in the 5-gallon rate and 23 infected tubers in the 4-gallon treatment. Very few infected tubers were present in the check plot, indicative of considerable variation in the uniformity of the infestation.

Laboratory and greenhouse studies have shown that the potato rot nematode will feed and reproduce on a large number of different species of fungi (2, 6). Therefore, it was felt that a fungicide-nematocide combination treatment might give similar results but allow a reduced rate of EDB. A heavily infested plot was selected for this study in 1956. Four soil fungicides were applied (broadcast) alone and in combination with a 2- and 2-gallon split plow application of EDB. Potatoes were planted in the spring of 1957. Final notes taken at harvest showed the fungicide-nematocide combinations to be free from any infected tubers, but poor control was obtained with each of the fungicide treatments. The incidence of the infestation varied considerably within and between treatments including the check, emphasizing the extreme variability of an infestation of this pest.

The use of EDB as a soil fumigant involves possible harmful bromide residues in potatoes grown on treated land. Random samples of tubers were collected in 1956 from nontreated as well as plots treated (6-gallon rate) in 1955 and submitted to the Dow Chemical Company, Midland, Michigan, for analyses[3]. Their data show bromide residues ranging from 5.6 to 53 ppm with an average of 19.1 for treatments and from 1.6 to 15 ppm with an average of 5.6 ppm for nontreated checks. Samples taken from the 24-acre field show residues dropping from an average of 13.7 ppm in 1956 to 8 ppm in 1957 in the treated area and from 5 ppm to 1 ppm in the nontreated check. The Dow Chemical Company petitioned Federal Pesticide Regulatory Agencies for a tolerance of inorganic bromide residues resulting from soil treatment with EDB and has obtained a 75 ppm tolerance for restricted use in Wisconsin and Idaho.

DISCUSSION

By employing 4- and 2-gallon split plow sole applications of EDB, a level of control of the potato rot nematode approaching eradication has been obtained under Wisconsin conditions since 1954. Although soil fumigation for the control of nematodes is rapidly becoming an established practice in many areas, it is felt that certain aspects of the problem dealt with here should be emphasized.

The complete kill obtained depends upon thorough penetration of the soil by EDB in amounts sufficient to be lethal to the nematode. A temperature of 50° F, the minimum accepted for application, not only affects penetration by reducing volatility of the nematocide but influences application date. During the course of these and other experiments soil temperatures above 50° at application depth do not usually occur in Wisconsin until late May or early June. Fumigation started in early June necessitates an extremely late planting date for potatoes and usually results in unprofitable production; toxicity to the plants was present and resulted in depressed yields. Actually there are few, if any, crops that can be grown during the summer season following spring treatment. On the other hand, soil temperatures are consistently within a range desirable for treatment in early September. Fall treatment permits seeding of an early spring cash crop that can be harvested prior to treatment.

Plow application had certain advantages over a chisel applicator particularly in those areas of a field containing cobblestone. Under such conditions the plow maintained a uniform depth

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[3] The author wishes to thank the Dow Chemical Company for the bromide analyses.

but the chisel did not. It is necessary to turn under the top 2 or 3 inches of soil on the second application, an adjustment which is easily accomplished on a plow. In addition it is possible to place the fumigant in a wider band on a plow sole, undoubtedly a factor that aids penetration by the fumigant.

Since a very high level of control was obtained with EDB and since the tests were conducted on acreages sufficiently large to include areas of extremely heavy infestations, the question of possible eradication arises. Because of the hazard of contamination, it is possible that fumigation alone would not accomplish total eradication. However, when fumigation is combined with the restrictions imposed by the present quarantine in Wisconsin designed to eliminate its spread, this possibility is reduced to a minimum. For example, regulations prohibit production of potatoes on infested land, regulate grade, supervise disposal of all culls or pick-outs from an infected lot, limit containers to nonreusable paper bags and restrict sale to approved markets. The effectiveness of this program in restricting the spread of this pest has been demonstrated through a continuous survey being conducted annually. Cost of application is not prohibitive, being about $40 an acre. As a result, a total of 250 acres has now been treated on which the program can be further evaluated.

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THE CONTROL OF COTTON ROOT-KNOT BY THE ADDITION OF 1,2 DIBROMO-3-CHLOROPROPANE TO IRRIGATION WATER[1]

Donald J. Morton[2]

Abstract

1,2 dibromo-3-chloropropane in irrigation water was found to control cotton root-knot to a very high degree, increase cotton yields an estimated 117 percent (0.7 bales/acre), and slightly decrease seedling stand counts. It is likely that one application will be effective for at least 2 years, and thus reduce the cost below that of commercial row treatments. These factors together with the elimination of certain disadvantages of tractor application make this method of applying nematocides appear promising for fields with extensive populations of root-knot nematodes.

INTRODUCTION

A convenient method of applying some agricultural chemicals in irrigated regions is to incorporate them in the water supply. There are numerous reports of fertilizer applications by this technique, and Reynolds and O'Bannon[3] recently described the reduction of citrus nematode populations by applying an emulsifiable formulation of 1,2 dibromo-3-chloropropane in irrigation water. It was decided to attempt control of cotton root-knot by this method, since conventional means of chiseling nematocides into the soil have certain disadvantages; for example, an extra tractor operation must be made, the chisels break open seed beds before planting, distribution of the chemicals throughout the soil is not uniform, and treatments often must be applied every year.

MATERIALS AND METHODS

An irrigated cotton field with rows about 311 feet long was found to have a general infestation of root-knot nematode (Meloidogyne sp.). The field was divided into three main areas: a central section of approximately 2 acres where the nematocide was applied, and two adjacent areas on each end where only water was put on. The chemical selected was an emulsifiable form of 1,2 dibromo-3-chloropropane[4], since this material appeared to have the most promise for such a test. Water was supplied from a ditch that ran through a flood gate about 200 feet from the field, and the chemical was added at this gate so that it would be well mixed with the water when it reached the field. Applications were made during the preplant irrigation 10 days before the cotton[5] was planted.

Water was applied first to the two control areas, which were later closed off while excess water was drained from the supply ditch. The rows to be treated were then opened, and the chemically-treated water was run into the field. The rate of application was regulated by knowing the area to be treated and the time necessary for its irrigation, and then adding the desired amount of nematocide at a constant rate for this period of time. One gallon of actual 1,2 dibromo-3-chloropropane per acre in an emulsifiable form was used, as this corresponds to the recommended broadcast rate on cotton.

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2 Assistant Nematologist, New Mexico Agricultural Experiment Station, State College, New Mexico. The assistance and suggestions of Leslie Clayshulte of Agricultural Products Company, Mesquite, New Mexico, are gratefully acknowledged.

3 Reynolds, H. W., and J. H. O'Bannon. 1958. The citrus nematode and its control on living citrus in Arizona. Plant Disease Reptr. 42: 1288-1292.

4 Chemical supplied through the courtesy of the Shell Chemical Comporation. The active ingredient was 1,2 dibromo-3-chloropropane and the form used consisted of 8.6 pounds of actual chemical in each 1 gallon of emulsifiable concentrate.

5 Variety Acala 1317C.

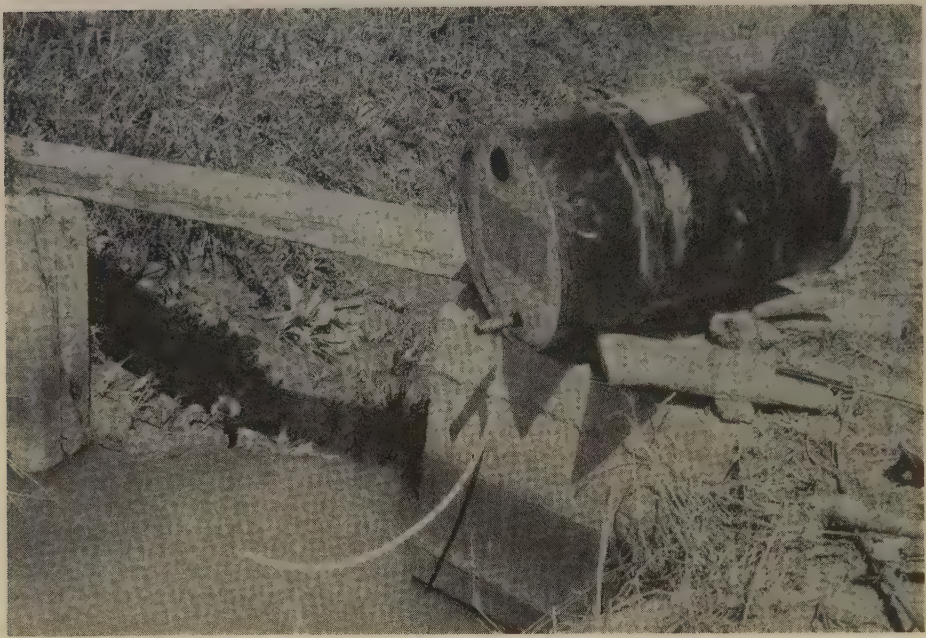

FIGURE 1. Barrel fitted with plastic faucet and tubing from which the nematocide was released into the irrigation stream.

A rather simple arrangement was used to add the chemical to the water. The nematocide was poured into a 30-gallon barrel fitted with a plastic faucet and tube (Fig. 1). The time needed to irrigate the treated area was 100 minutes, so the chemical was diluted with water to 25 gallons and run from the barrel into the center of the irrigation stream at a rate of 1 quart per minute. An attendant checked the rate of flow for 5 seconds every few minutes, and adjusted the faucet to compensate for the gradually reducing head. The system worked well and the actual time of application came within 2 minutes of the estimated time.

RESULTS

Three types of information were obtained from this test: 1) stand counts, 2) cotton yields and 3) root-knot indexes. Two rows at each side of the treated section and two rows in each of the adjoining control areas were used as representative plots; the control plots at each side were separated from the treated ones by only a border row.

Cotton seedlings were counted 3 weeks after planting. As shown in Table 1, stand counts were slightly lower and numbers of dead seedlings (undetermined cause) slightly higher in the treated rows. On the other hand, treated cotton plants grew appreciably faster than untreated ones (Fig. 2).

Cotton yields were estimated from the number of burrs left after picking. On this basis, it was calculated that treated rows yielded an average of 117 percent more (0.7 bales/acre) than untreated rows (Table 2).

A striking difference was found in the root-knot indexes of the different plots (Table 3). Only one galled plant was found in the sampling of treated rows, and this showed only a trace of knotting. Tap-root growth was long and clean, suggesting deep penetration of the nematocide into the soil. In contrast, all untreated roots examined exhibited considerable galling and had stubby, knotted tap roots. Typical specimens of roots are illustrated in Figure 3.

DISCUSSION

The addition of 1,2 dibromo-3-chloropropane to irrigation water almost completely controlled cotton root-knot, and resulted in an average yield increase of 117 percent. Such information should establish this means of applying nematocides as being commercially feasible, since the virtual lack of galling in the treated area indicated that one treatment should be effective for at least 2 years, according to local commercial experiences. This would make

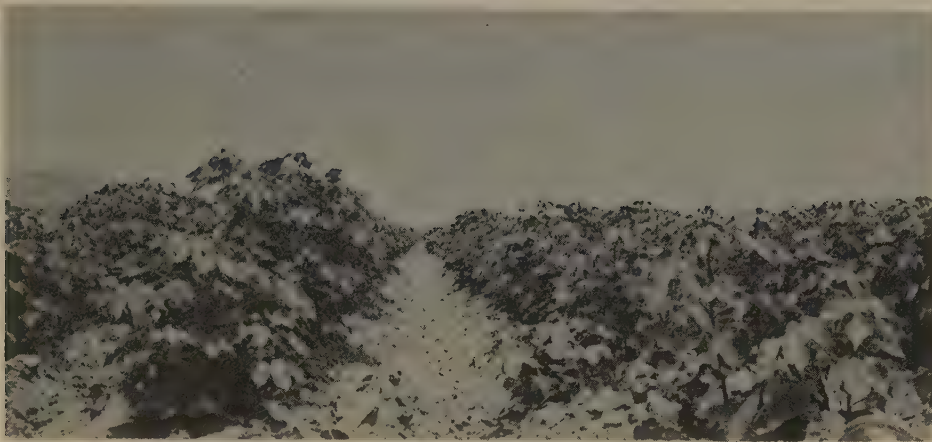

FIGURE 2. Comparison of 50-day-old plants from treated (left) and untreated (right) rows. Note the increased height of plants in the treated soil. The row on the left is a border row, and received nematocide from only one side.

FIGURE 3. Comparison of cotton roots from treated (left) and untreated (two on the right) soil. Note the longer tap root and the absence of knotting on the root from treated soil. Roots shown represent average and not extreme samples.

Table 1. Total number of seedlings counted in two 50-foot row lengths per plot (100 feet total) 3 weeks after planting. Counts of dead seedlings are given in parenthesis.

Treatment	Number of seedlings per 100 feet of row		
	Plot A	Plot B	Average
Control	855 (4)	813 (17)	834 (11)
Nematocide	874 (25)	739 (20)	760 (22)

Table 2. Estimated number of bales per acre from treated and untreated plots. Estimates are based on the numbers of burrs remaining in 10-foot row samples, and each plot figure represents an average of six such samples.

Treatment	Estimated bales per acre		
	Plot A	Plot B	Average
Control	0.35	0.85	0.60
Nematocide	0.97	1.55	1.30
Increase			0.70
Percent increase			117 percent

Table 3. Average root-knot indexes of 20 plants dug after harvest from treated and untreated plots.

Treatment	Plot A	Plot B	Average
Control	3.60	1.20	2.400
Nematocide	0.05	0.00	0.025

Scoring System: 0 -- 0 percent of roots galled; 1 -- 0-25 percent of roots galled; 2 -- 25-50 percent of roots galled; 3 -- 50-75 percent of roots galled; 4 -- 75-100 percent of roots galled.

an application less costly than current commercial row treatments, which must be applied yearly. In addition, there is the possibility that lower rates of 1,2 dibromo-3-chloropropane in irrigation water might be effective, thereby further lowering the cost. This suggestion is supported by the fact that plants in border rows between treated and untreated areas received nematocide on only one side of the row, and yet were as free of root-knot as those in fully treated rows. Also, the elimination of one tractor operation and of the passage of chisels through a prepared seedbed together with the apparently uniform distribution of the chemical in the soil should help make this means of application desirable where root-knot nematodes infest large portions of fields.

The fact that stand counts were slightly lower in treated areas did not affect cotton yields, since all rows were overplanted and later thinned to the same spacings. The counts after thinning were the same for all plots.

The method of adding the nematocide to the water was quite simple in this experiment. More refined equipment may be designed for commercial operations, two examples of which are illustrated by Reynolds and O'Bannon .

NEW MEXICO AGRICULTURAL EXPERIMENT STATION, STATE COLLEGE, NEW MEXICO

THE USE OF A GRANULAR NEMATOCIDE APPLIED AT LISTING IN CONTROLLING COTTON ROOT-KNOT[1]

Donald J. Morton[2]

Abstract

Granules containing 8.6 percent Nemagon were listed into seedbeds 29 days before planting, and compared with certain liquid nematocides applied 4 days later for effectiveness in controlling cotton root-knot and increasing yields. The granular applications had certain advantages over the liquid ones; for example, the expense of specialized equipment and an extra tractor operation were omitted, the seedbeds were not damaged by injection chisels, and it was not necessary to fit the application between cultural practices.

Under these conditions of early application, all nematocides were associated with significant increases in yield, but Nemagon S-1 at both rates and Fumazone at the higher rate were significantly better than Nemagon granules at the lower rate or Dowfume W-85. All nematocides significantly reduced root-knot; the plants in soil treated with Nemagon granules showed more galling than those where Fumazone or Nemagon S-1 were used, but less than where Dowfume W-85 was applied.

It is concluded that granular applications in this manner would be preferable to liquid application of the same material only when the added expense and inconvenience of applying liquid nematocides is not justified by the higher yields obtained.

INTRODUCTION

The culture of cotton in the Mesilla Valley of New Mexico varies in some ways from that in humid areas where furrow irrigation is not practiced. In this arid region soil is prepared in the spring and then listed into beds crested several inches above the original soil level. The furrows are then irrigated and later, just before planting, the peaks of the beds are dragged off and seed are planted in the moist bed centers.

The applications of nematocides must be made in conjunction with these practices. Often, soil injections are made through chisels run 11 to 12 inches deep along the beds, sometime between 1 and 4 weeks prior to planting. Although this method usually gives economic control of root-knot, it has the disadvantages of requiring a separate operation which must be fitted between the other cultural practices, and it requires specialized injection equipment for application. Also, the chisels may open the beds in such a way that soil moisture escapes through the openings, and air pockets in the soil may be formed which will hinder seed germination. Because of these factors it was decided to attempt to control cotton root-knot by applying granular nematocides with standard farm equipment at listing.

MATERIALS AND METHODS

Front-mounted fertilizer sidedressers were attached to a tractor equipped with rear-mounted listers and sidedressers. Nemagon granules (8.6 percent[3]) were applied on the soil

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[3] Active ingredient supplied through the courtesy of the Shell Chemical Corp. Nemagon granules in this paper refers to a formulation of 1,2 dibromo-3-chloropropane produced by the Agricultural Products Co., Mesquite, New Mexico, by spraying technical Nemagon on ataclay base granular pellets to form granules with 8.6 percent active nematocide. Material was kept in sealed polyethylene bags until application.

FIGURE 1. Application of Nemagon granules from front-mounted sidedressers. Rear-mounted sidedressers are shown applying fertilizer, while listers are covering both materials with soil.

surface from the front-mounted sidedressers[4], fertilizer from the rear-mounted ones, and listers covered them both with several inches of soil (Figure 1). Since 5 inches of these beds were later dragged off, the final depth of nematocide placement was only about 2 inches below the final soil level. It was hoped that the irrigation which followed 9 days after listing, together with the considerable length of time before planting (29 days), would enable the chemical to penetrate deeper into the soil. Soil temperature and moisture at the time and depth of application were 12° C and 12.9 percent, respectively.

The granules were tested at two rates: 100 and 150 pounds per acre (equivalent to 1/2 and 3/4 gallons per acre, respectively, of active ingredient). These were compared with liquid applications of Nemagon S-1[5] and Fumazone[6] at 2 and 3 gallons per acre (1/2 and 3/4 gallons per acre, respectively, of active ingredient) and of Dowfume W-85[6] at 2 gallons per acre (about 1 1/2 gallons per acre of active ingredient), as well as with a control. All liquid nematocides were injected from a commercial pressure applicator[7] through chisels run one per row 10 to 11 inches deep in the listed beds. As 5 inches of soil were dragged off, just prior to planting, the depth of placement corresponded to about 6 inches in the final seedbed. The liquid nematocides were injected 4 days after the granular application (25 days before planting), and soil temperature and moisture at injection depth were 14° C and 12.4 percent, respectively, at the time of application.

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4 This design was suggested, in part, from an unpublished report of John D. Gilpatrick, former Assistant Nematologist at the New Mexico Agricultural Experiment Station.

5 Chemical supplied through the courtesy of the Shell Chemical Corporation, and contained 4.3 pounds per gallon of 1,2 dibromo-3-chloropropane.

6 Chemicals supplied through the courtesy of the Dow Chemical Co. Fumazone contained 4.3 pounds per gallon of 1,2-dibromo-3-chloropropane; Dowfume W-85 contained 12 pounds per gallon of 1,2 dibromoethane.

7 All liquid chemicals were applied through the courtesy of the Agricultural Products Co., Mesquite, New Mexico.

A sandy field with a general infestation of root-knot nematode (Meloidogyne sp.) was located for the test. Four replications of each treatment were used in a randomized block design; each replication consisted of four adjacent rows in which the middle two were used for obtaining information. Row lengths averaged about 607 feet, or 1214 total footage for the two rows evaluated. Yield data and root-knot indexes were the main criteria used to determine the effectiveness of the treatments, and a cotton variety particularly susceptible to root-knot, Pima S-1, was employed in the test.

RESULTS

On the basis of yield data from both pickings, all treatments were significantly better than the control (Table 1). Nemagon S-1 at both rates and Fumazone at the higher rate were associated with the best yields. They were significantly better than the Dowfume W-85 and the lower rate of Nemagon granules, but not the higher rate of granules nor the lower rate of Fumazone.

Table 1. Cotton yields from various treatments represented as pounds of seed cotton per acre. Each plot approximated one-tenth of an acre, so original values were about 10 percent of those listed below.

Treatment	Rate/Acre	Yields in Pounds/Acre				
		Block A	Block B	Block C	Block D	Average
Control	--	1913	1518	1148	1091	1417a[a]
8.6 percent Nemagon granules	100 pounds	1892	2253	1917	1654	1952b
Dowfume W-85	2 gallons	2233	2139	1818	1688	1970b
8.6 percent Nemagon granules	150 pounds	2200	2278	2112	1725	2079bc
Fumazone	2 gallons	2279	2244	2133	1726	2095bc
Fumazone	3 gallons	2260	2404	2230	1751	2161c
Nemagon S-1	2 gallons	2532	2424	2035	1849	2210c
Nemagon S-1	3 gallons	2442	2506	2246	1850	2261c

[a] Any pair of means not followed by the same letter are significantly different at the 5 percent level of probability, as determined by Duncan's Multiple Range Test (1).

Table 2. Root-knot indexes of cotton plants in the different treatments. Each figure represents an average of ten randomly selected plants.

Treatment	Rate/Acre	Root-knot Indexes				
		Block A	Block B	Block C	Block D	Average
Control	--	3.8	4.0	3.8	4.0	3.9a[a]
Dowfume W-85	2 gallons	2.5	3.7	2.7	3.8	3.2b
8.6 percent Nemagon granules	100 pounds	3.3	3.0	2.6	2.5	2.9b
8.6 percent Nemagon granules	150 pounds	2.6	2.1	2.4	2.3	2.4c
Nemagon S-1	2 gallons	1.7	1.8	1.3	1.1	1.5d
Nemagon S-1	3 gallons	1.4	1.7	1.3	1.0	1.3d
Fumazone	2 gallons	1.0	1.9	1.0	1.3	1.3d
Fumazone	3 gallons	1.0	1.2	1.0	1.0	1.1d

[a] Any pair of means not followed by the same letter are significantly different at the 5 percent level of probability, as determined by Duncan's Multiple Range Test (1).

Scoring System: 0 -- 0 percent of roots galled; 1 -- 0-25 percent of roots galled; 2 -- 25-50 percent of roots galled; 3 -- 50-75 percent of roots galled; 4 -- 75-100 percent of roots galled.

Root-knot indexes showed that plants in all treatments had significantly less galling than did those in the control (Table 2). The two rates of Nemagon S-1 and of Fumazone showed significantly greater control than did either rate of granular applications or the Dowfume W-85, while the higher dosage of granules was significantly more effective.

A visual comparison of cotton growth 2 months after planting showed that all treatments were associated with increased plant size over that in the control, but no differences between treatments were noted. An example of this increased growth may be seen in Figure 2.

FIGURE 2. Growth of plants in the control (right) and in rows treated with Nemagon granules (left). Note increased growth in the treated rows.

DISCUSSION

Data in Tables 1 and 2 show that 8.6 percent Nemagon granules were associated with significant increases in cotton yields and decreases in root-knot, compared with the control. However, Nemagon S-1 at both rates and Fumazone at the higher rate were significantly more effective in both respects than were either the granules or Dowfume W-85. Dowfume W-85 compared favorably with the Nemagon granules with respect to yield, but was not as effective in reducing root-knot.

It should be pointed out that 1) the active ingredient of Dowfume W-85 (1,2 dibromoethane) has a vapor pressure almost 20 times greater than that of 1,2 dibromo-3-chloropropane (the active ingredient of Nemagon and Fumazone) at the soil temperature present during application and 2) root-knot nematode eggs in galled roots show much greater resistance to these nematocides than do root-knot larvae (2). Since the treatments were applied before a large portion of eggs would have been expected to have hatched, it is likely that the 1,2 dibromoethane was mostly dissipated before larval populations were great enough to be important. The 1,2 dibromo-3-chloropropane, on the other hand, probably remained in the treated area for a much longer period, and thus would have been still effective after many of the larvae had emerged from their eggs.

The results suggest that, of the nematocides tested, Nemagon S-1 would be preferable for cotton root-knot control when its application is not too costly and does not seriously interfere with cultural practices. If the expense of the extra tractor operation and specialized equipment together with the added disadvantages of injection chisels opening the seedbeds and cultural practices interfering with applications should be particularly important, then listing

Nemagon granules into the row would appear promising as a means of economically controlling cotton root-knot.

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NEMATODES ASSOCIATED WITH VARIETAL YIELD DECLINE OF SUGAR CANE IN HAWAII[1]

Harold J. Jensen[2], J. P. Martin[3], C. A. Wismer[4] and H. Koike[5]

Summary

Nematodes have been investigated since 1906 by the Experiment Station, Hawaiian Sugar Planters Association (H. S. P. A.), as a possible cause of sugar cane varieties failing to maintain their original yields. Surveys conducted then and in 1929 of sugar cane roots and soil showed that two species of nematodes, a root-knot and a burrowing nematode, were widely distributed in sugar cane-growing areas. It was concluded from these earlier investigations that there was insufficient evidence to show that nematodes alone caused a recognizable growth failure in the field.

In view of recent developments in the field of nematology, in 1954 the Pathology Department renewed its nematode investigations. The objective of the current nematode study is to determine the role nematodes are playing in the yield decline of commercial sugar cane varieties. Nematodes are associated with the following abnormalities of sugar cane: (a) malformations (galls) of the root system; (b) retarded root development, such as stubby-root; and (c) necrotic areas in the roots which usually develop into root-rots. While various nematodes undoubtedly cause considerable injury to cane roots by direct feeding, potentially nematodes are even more serious in providing avenues for secondary infections by fungi, resulting in root rots. Eight genera of plant parasitic nematodes were found associated with sugar cane root systems. Three of these (root-knot, root-lesion, and spiral nematodes) are believed to be the most important because they are very numerous and are frequently found in or attached to the roots.

The absence of characteristic field symptoms continues to be a serious handicap in diagnosing nematode damage to sugar cane. Evidence of infection can be observed only when portions of the root system are uncovered. In greenhouse tests, sugar cane seedlings were found to be useful indicators of nematode injury. The growth of seedlings exposed to various combinations of nematodes associated with cane roots was reduced by 30 to 60 percent. Adverse growing conditions may be necessary to demonstrate symptoms of retarded growth when single-eye cuttings are used, because of the reserve food stored in the seed piece.

The populations of parasitic nematodes appear to have reached their peak during the first 8 to 10 years of cane production. Apparently the monoculture conditions of sugar cane production do not favor a continuous rise in the parasitic nematode population. Results of recent nematode surveys compared with those of the past reveal: (a) the disappearance of some natural enemies, such as the Mononchus spp.; (b) increases in the populations of some nematodes (root-knot and root-lesion) and declines in others (burrowing nematodes); and (c) wider distribution of the eight genera of nematodes now considered as potential pests of sugar cane.

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Numerous soil fumigation plots on different plantations throughout the sugar producing areas have given erratic results. However, the excellent results from several of these tests are encouraging and indicate that soil fumigation may be an economic practice in some areas. Two important reasons for the failure of sugar cane to respond to soil fumigation treatments are the spotty distribution of nematodes, and inadequate soil preparation. The role of nematodes in restricting sugar cane production, and soil fumigation to improve yields continue to be important phases of sugar cane pathology.

INTRODUCTION

Nematodes as a cause of declining sugar cane yields have been investigated at the Experiment Station of the Hawaiian Sugar Planters Association at intervals beginning in 1906. In that year, N. A. Cobb began a survey of plantation soils for nematodes. This investigation resulted in the description of 19 new species of nematodes associated with cane stools (2). In 1909, Cobb (3) described the injury to cane roots caused by two species of nematodes, Meloidogyne incognita var. acrita (described as Heterodera radicicola) and Radopholus similis (described as Tylenchus biformis). He suggested the following remedies to reduce the nematode population: trapping, resistant or tolerant varieties, destructive chemicals, heat, and various cultural practices.

During the late 1920's and early 1930's, Cassidy (1), Muir and Henderson (6), and Van Zwaluwenburg (7, 8) again made nematode investigations which included a survey of plantation soils. This survey indicated that the two species of cane-inhabiting nematodes, Meloidogyne incognita var. acrita, a root-knot nematode, and Radopholus similis, now called the burrowing nematode, were widespread in plantation soils. Studies were also conducted on the general ecology of these species in relation to moisture, elevation, soil type, and cane varieties.

These early investigators concluded that there was insufficient evidence to show that nematodes alone cause recognizable growth failure in the field. Their conclusion seemed to be substantiated in that it was possible to produce good yields even when root-infecting nematodes were numerous. Van Zwaluwenburg's (9) paper to the 4th International Society of Sugar Cane Technologists was concluded by the following statement: "The investigations of nematodes as pests of sugar cane in Hawaii continues but these parasites are not regarded with alarm. It is the writer's opinion that as cane pests, nematodes hold a distinctly minor rank under present Hawaiian conditions." Since the early 1930's, a great deal of information about nematodes has become available. New studies relating to their identity, life history, host range, distribution, general ecology, and control are continually being reported. It is now established that these pests do not necessarily work alone; many are involved in root-rot complexes and yield decline of other crops. Progress has also been made in the control of nematodes by soil fumigation. In view of these developments and the search for causes of yield decline, the Experiment Station of the H.S.P.A. has again initiated nematode investigations.

NEMATODES ASSOCIATED WITH SUGAR CANE ROOTS

There are two major groups of nematodes associated with sugar cane. The first group, or endo-parasitic nematodes, enter and live in the root tissues. These pests have long been regarded as plant pathogens. Recently a second major group, called ecto-parasitic nematodes, has been the subject of intense investigations. These nematodes feed periodically on roots but live in the soil.

Endo-Parasitic Nematodes

The only nematodes considered to be a threat to the sugar industry by earlier investigators were two endo-parasitic nematodes. The major emphasis of nematological research then was an investigation of the various activities of the burrowing and the root-knot nematodes. More recently root-lesion nematodes have been recovered in large numbers from cane roots and soil samples. The root-lesion nematode is potentially as harmful to Hawaiian sugar cane culture as are the other endo-parasitic species mentioned.

Burrowing Nematode, Radopholus similis (formerly described as Tylenchus spp. or Tylenchus biformis):

The burrowing nematode received the major emphasis of earlier nematode investigations. The standard cane varieties of the past, Yellow Caledonia, H-109, D-1135, and Yellow Tip were all susceptible to injury by the burrowing nematode. Yellow Caledonia appeared to be the most severely injured. The nematode usually lived in the root cortex, although the stele was sometimes invaded. Infected roots showed numerous longitudinal lesions which first were a vermillion or cinnabar-reddish color. Later the lesion became dark purple in color and finally black. As the tissues rotted the nematodes tended to migrate from the area. The following generalizations regarding this pest were made after the completion of early surveys:

A. There is a definite correlation between elevation and nematode population; as the elevation increases, the population decreases. These nematodes are rarely found above 2000 feet.

B. The age of the cane, rather than the field cycle, is correlated with infection (although this may tend to vary with some varieties). The peak of infection is reached between 12 to 16 months and declines as the cane becomes older.

C. The nematodes are susceptible to drought conditions. Less than 30 inches of rain during a 3-month period will cause a reduction in the nematode population. Likewise, 75 inches of rain during the same period apparently produced saturation and other adverse conditions which reduced the nematode population.

The burrowing nematode situation has changed a great deal in the last three decades. Formerly, 65 percent of all plantation soils and 50 percent of all stools examined contained this pest. Today it can be estimated that less than 10 percent of the soil or stools will harbor it. Thus, in view of the apparent population decline of the burrowing nematode it is now considered of less importance.

Root-Knot Nematode, Meloidogyne incognita variety acrita (formerly Heterodera radicicola:

The root-knot nematode also received a great deal of emphasis in earlier investigations. The common name "root-knot" implies that this particular nematode (one of six described species) produces the swollen areas on the roots commonly known as "galls" (Fig. 1).

FIGURE 1. Note the occurrence of the swollen area or "gall" in the roots of sugar cane. The presence of galls indicates root-knot nematodes are present. Note the two spherical bodies, or females, shown within the gall.

The presence of numerous galls and excessive secondary root formation gives the infected root system a matted appearance. Many previous publications illustrate the symptoms produced by this pest on Yellow Caledonia, Lahaina, and H-109. The nematode infects many other varieties including those commonly grown today. Some of the conclusions made from previous investigation are as follows:

A. This nematode was believed to be less important than the burrowing nematode because the gall formation did not lead to breakdown of the root system.

B. As the altitude increased, the root-knot nematode population increased. This is a complete reversal of the pattern of burrowing nematode infections.

C. This pest seems to prefer the light, well-drained soils.

Earlier investigators were hopeful that a fungus parasite, Micocera spp., frequently recovered from gravid females, would reduce the nematode populations. They also hoped the

then common genus of predaceous nematodes, Mononchus spp., would be instrumental in reducing the population of root-knot and burrowing nematodes. Unfortunately biological control has not caused a noticeable reduction in the root-knot nematode population. The predaceous nematodes have practically disappeared from plantation soils. Now the population of root-knot nematodes seems to be greater than ever. Where formerly 35.6 percent of the plantation soils and 40 percent of the stools were infected, root-knot nematodes are now recovered from 70 percent of the soils examined. Reports from Australia, Taiwan, and other areas indicate that this nematode is one of the serious disease problems in cane fields. Thus, the root-knot nematode continues as one of the important sugar cane disease problems.

Root-Lesion Nematode, Pratylenchus brachyurus (formerly Tylenchus brachyurus): This root-lesion nematode was described by Godfrey (5) as a common inhabitant of pineapple roots in 1929. He suggested that it was distributed over most of the pineapple-growing areas of the Islands, but there were some fields where none had been found. In his article, Godfrey mentioned that F. Muir had told him (personal communication) that he had seen this nematode in sugar cane, but not extensively. Recent surveys have indicated that this pest is now very common in sugar cane soils and, in many instances, very abundant in the roots.

The root symptoms are similar in some respects to those listed for burrowing nematodes; The differences in color of infected tissues have not been observed, but the nematodes seem to prefer the cortex of the roots. Infected roots stained with acid fuschin in lacto-phenol and then cleared by lacto-phenol provides an easy method for observing these pests. Adults, various larval stages, and bean-shaped eggs can be found in the cortex tissue adjacent to the stele. Also seen in this preparation is a zone of brownish coloration which nearly always accompanies the nematodes (Fig. 2). This zone of coloration represents secondary invasion

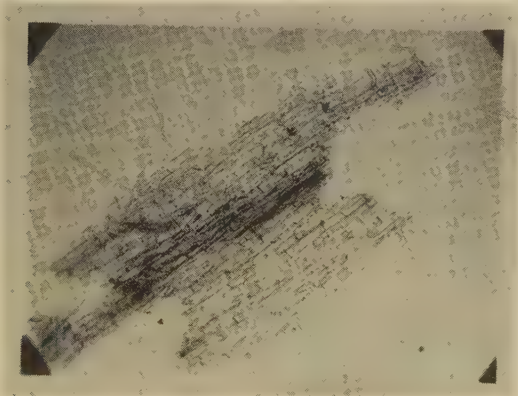

FIGURE 2. Longitudinal section of a sugar cane root stained to show the presence of root-lesion nematodes and affected tissue. The granular or darkened appearance of tissue adjacent to the nematodes indicates a secondary infection due to fungi and bacteria which nearly always accompany these pests.

chiefly by bacteria and fungi. The secondary invasion by microorganisms may be more serious than the initial invasion by the nematodes. The migratory nature of these pests, moving from one area of a root to another area, from root to root, or from plant to plant, greatly accelerates the amount of root damage. Eventually the cortex sloughs away and the roots collapse. Their common occurrence, abundance in the roots, and association with secondary infections, make these nematodes the most important of those now being investigated.

Ecto-Parasitic Nematodes

Recent Pathology Department surveys of plantation soils reveal numerous ecto-parasitic nematodes associated with sugar cane roots. The parasitic relationship of this group of pests is difficult to establish, since they are rarely found attached to the roots. Thus, different techniques and methods of study are necessary. The ecto-parasitic nematodes are usually associated with the following plant symptoms:

A. Inferior root system characterized by absence of feeder roots and retardation of primary and secondary roots; and

B. Root deterioration or rot with associated invasion by secondary organisms.

The following five genera of ecto-parasitic nematodes are considered to be potential sugar cane pests.

Spiral Nematode, Helicotylenchus nanus (formerly Tylenchus spiralis):

The spiral nematode is common in plantation soils; in fact, it is extremely rare to examine a plantation soil that does not contain this nematode or a closely related species. Cassidy stated in 1930 (1) that this species is commonly associated with the roots of sugar cane and other crops. She also stated that the species is distributed throughout the Islands and apparently is not influenced by altitude or by varied soil environment.

It is extremely difficult to observe these and other ecto-parasites in the act of feeding because they feed periodically and normal handling and processing manipulations are likely to dislodge them from the root tissue. However, several specimens have been observed with their heads firmly embedded in the root tissue (Fig. 3). Many of these entrapped forms were accompanied by the discoloration of secondary infection which has been described for root-lesion nematodes. The spiral nematodes are considered sugar cane pests because: (a) they are the most numerous forms found in plantation soils; (b) they have frequently been observed feeding on roots; (c) the feeding sites exhibit evidence of secondary infection.

FIGURE 3. Longitudinal section of a sugar cane root stained to reveal the presence of a spiral nematode partly embedded in the tissue. Note the darkened appearance of the root tissue adjacent to the nematode; this indicates secondary infection.

Stubby Root Nematode (Trichodorus christiei and T. porosus):

Stubby root nematodes were mentioned in the 1956 Experiment Station report (4) as one of three genera considered most harmful to sugar cane. Stubby root nematodes are considered serious pests in the southeastern part of the United States. They are associated with many retarded root conditions of vegetables. The injury is usually confined to developing primary and secondary roots. The root system of an injured plant is almost completely devoid of feeder roots, although a few short stubby remnants may be found. Secondary infections are likely to accompany this injury.

According to recent surveys, the distribution of the stubby root nematodes are sporadic, but when they occur, the population may surpass those of other nematodes associated with sugar cane. Experiments using Trichodorus-infected soil resulted in retarded cane growth.

Dagger Nematode, Xiphinema spp. (probably two undescribed species):

Dagger nematodes are the largest nematodes associated with sugar cane roots. They are characterized by an extremely long and well-developed spear. Recent investigations elsewhere have indicated that this group of nematodes is responsible for some serious plant disease conditions, ranging from gall-like formations and absence of feeder roots to symptoms similar to stubby-root conditions.

Recent surveys of plantation soils indicate a distribution pattern similar to that of stubby root nematodes and other ecto-parasitic nematodes associated with sugar cane roots.

Ring Nematodes (mostly Criconemoides sphaerocephalum):

Ring nematodes are characterized by conspicuous annules (rings). The short thick body, sluggish movement, and well-developed spears are typical for this genus. Injury by these nematodes, like that of other ecto-parasites, is associated with absence of feeder roots and presence of short stubby root-remnants.

Plantation surveys indicate a distribution similar to that of the other ecto-parasites, although the ring nematodes seem to be most numerous in porous well-drained soils. The role of these nematodes is uncertain, but, when numerous, cannot be ignored.

Pin Nematode, Paratylenchus minutis:

Pin nematodes are occasionally recovered in great numbers from plantation soils. The exact parasitic relationship of this group is difficult to establish. However, pin nematodes are serious pests of pineapples and other island crops. Thus, they should be considered as potential pests, especially where the population is great.

DISCUSSION

The three nematode pests now believed to affect sugar cane culture in Hawaii are two endo-parasites (root-knot and root-lesion) and one ecto-parasite (spiral). We have frequently recovered these nematodes from sugar cane root tissue (Figs. 1, 2, 3). The distribution of these pests usually coincides with that of the sugar cane-production areas.

Root-knot nematodes (Meloidogyne incognita var. acrita) are very numerous in most sugar cane-growing areas. The presence of these pests in cane roots is rather easy to observe because of the conspicuous galls produced. In seedlings they cause considerable retardation of growth (Fig. 4). It has not been possible to diagnose the presence of this pest by the growth behavior of above-ground portions of the cane plants. Reports from other sugar cane areas indicate the cane may be stunted severely and exhibit yellowish foliage. The infected cane usually shows the tendency to exhibit drought-like symptoms on hot days when soil moisture is normal. The areas affected may consist of occasional spots of a few square feet or may involve several acres.

Root-lesion nematodes (Pratylenchus brachyurus) have replaced the related burrowing nematode in importance as a root-parasite of sugar cane. In addition to injury caused by direct feeding, root-lesion nematodes are probably even more important as pests because of their association with fungi, bacteria, and other root-rotting organisms. The distribution of these pests is much more erratic than is that of the root-knot nematodes, which are usually not associated with tissue breakdown. Necrosis of the root tissue surrounding the root-lesion nematodes is usually much more extensive than that caused by other nematodes. There are no characteristic root symptoms to simplify field diagnosis.

The parasitic relationship of the spiral nematodes (Helicotylenchus nanus) is more difficult to establish since contact between the plant and this nematode is probably brief and periodic. Spiral nematodes are by far the most numerous of the eight nematodes regarded as potential pests of cane. Figure 5 shows the effect of this pest on seedling growth and Figure 3 illustrates the parasitic relationship.

The other five genera of nematodes are apt to be important in localized areas where they occur in large populations. The root damage of sugar cane attributed to nematodes is not likely to be caused by only one kind of nematode, but should be regarded as the result of composite action.

The absence of characteristic field symptoms is a serious handicap in diagnosing nematode damage. The expected symptoms of stunting of off-color foliage in fields having a high nematode population were not observed. The height and lodging characteristics of sugar cane present difficulties in observing symptoms once the cane reaches an age of approximately 8 months. Thus, infested soils containing various combinations of nematode pests were brought to the Station for growth-retardation studies.

One-half of each soil sample, containing the various combinations of nematodes, was treated to eliminate the pests; these served as controls. The remainder of each sample received no treatment. Single-eye seed-pieces and small seedlings were planted in the soils to indicate evidence of growth retardation.

There were no significant evidences of stunting of off-colored foliage obtained where seed pieces served as indicator plants. Adverse growing conditions, such as frequent ratooning or withholding irrigations, may be necessary to demonstrate symptoms because of the reserve food material stored in the seedpieces. Wismer (10) reported a 40 percent reduction in growth of cane after ratooning the plant crop in 5 months where grown in sterilized soil in 25 gallon drums and inoculated with a composite sample of nematodes. He also reported that retardation of growth was not as evident after subsequent ratoons.

Sugar cane seedlings are excellent indicators of growth retardation by various nematodes. Figures 4, 5 and 6 reveal some of the differences that were obtained. Growth retardation of 40 to 60 percent was not unusual. In most instances, there was no evidence of stooling after a growing period of two months. In the future it may be desirable to screen cane selections for nematode resistance. The use of small seedlings should aid in evaluating nematode damage to sugar cane.

FIGURE 4. A comparison of cane seedling growth attained from planting seed in root-knot infested soil (left), with soil sterilized (right) to eliminate nematodes. Each pot received the same amount of soil from the same source; the only difference being that the pot marked "sterilized" was treated to eliminate the nematodes. (1480 root-knot nematodes, Meloidogyne)

FIGURE 5. A comparison similar to that described in Figure 4, except in this case the soil was infested with spiral and other nematodes. (1600 spiral nematodes, Helicotylenchus; 1000 root-knot nematodes, Meloidogyne)

FIGURE 6. A comparison similar to that described in Figures 4 and 5, except the soil used in these trials contained several species of nematodes believed to be pests of sugar cane. (1540 spiral nematodes, Helicotylenchus; 1040 root-knot nematodes, Meloidogyne; 920 ring nematodes, Criconemoides; 260 root-lesion nematodes, Pratylenchus)

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PROGRESS REPORT ON GROWTH RESPONSES OF BURROWING NEMATODE INFECTED CITRUS FOLLOWING CHEMICAL TREATMENTS UNDER GREENHOUSE CONDITIONS

Julius Feldmesser, R. V. Rebois and A. L. Taylor[1]

Suit and DuCharme (2) produced symptoms of spreading decline of citrus by growing sour orange seedlings in cans of subsoil collected from areas of citrus groves showing this disease. As compared with similar seedlings grown in subsoil from healthy areas of the groves, the plants had greatly reduced top growth and smaller root systems. The seedlings showing spreading decline symptoms had brown lesions on the roots in which burrowing nematodes, Radopholus similis (Cobb, 1893) Thorne, 1949, were found, and this was considered strong evidence that the burrowing nematode is the causal agent in the decline.

In a series of experiments, we have eliminated nematodes from soil collected from spreading decline areas of citrus groves, but this has not resulted in elimination of spreading decline symptoms from citrus seedlings grown in the soil. The experiment described here was an attempt to eliminate fungi as a possible cause of the symptoms without eliminating burrowing nematodes.

Small Duncan grapefruit seedlings germinated in vermiculite were planted in soil collected from an area where spreading decline occurred naturally and maintained in the greenhouse. In April 1958, 2 months after planting, seedlings approximately 3 inches high with moderately severe chlorosis were selected and transplanted into 15 eight-inch clay pots of steam-sterilized soil, three to the pot, and thereafter maintained in the greenhouse.

Three pots were designated as controls. Drenches of captan wettable powder[2] were applied to the remainder in May and again at the same rate in June, the total amount being equivalent to 25 pounds, 50 pounds, 100 pounds or 200 pounds per acre of active material, calculated according to Smith (1). Captan (N-trichloromethyl mercapto-4-cyclohexene-1, 2, dicarboximide) was selected because it is known to be an effective fungicide and because it had little or no effect on nematodes when tested by the technique described by Taylor, Feldmesser and Feder (3).

The pots were maintained according to regular greenhouse practices until early October 1958. At this time all treated plants had a darker green coloration than the control plants. Nematode counts (Table 1) indicate that populations were not significantly different from the controls in any of the treatments.

Table 1. Average numbers of nematodes and average root and top weights and top heights of nine Duncan grapefruit seedlings five months after treatment of soil with captan.

Pounds per acre equivalent of captan	Radopholus and Pratylenchus per plant[a] (number)	Radopholus and Pratylenchus per gram of roots[a] (number)	Weight of roots (grams)	Weight of tops (grams)	Height of tops (inches)
Check	56.7	9.3	6.1	3.4	4.8
25	b	b	7.6	6.7	6.9
50	105.7	8.2	12.9	12.6	10.5
100	b	b	10.6	8.3	8.0
200	82.7	9.4	8.8	4.9	6.1

a More than 95 percent of the nematodes recovered were Radopholus similis, and less than 5 percent were Pratylenchus.

b Nematodes were present but were not counted in these samples since counts in next higher treatments did not differ significantly from those of the checks.

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[2] Especially formulated for this work by the California Spray-Chemical Corporation, Orlando, Florida.

FIGURE 1. Growth of Duncan grapefruit seedlings in soil treated with captan and in untreated soil. A -- Representative pots from all treatments. B -- Root systems of plants from all treatments. C -- All control plants and all plants in soil treated with 50 pounds of captan per acre.

The seedlings exposed to 50 pounds of captan per acre had root systems twice as heavy and tops more than three times as heavy as the controls (Fig. 1). Plants exposed to the 200 pound treatments showed very little improvement in color and made little more growth than the controls, possibly the result of chemotoxicity. Plants in pots treated with captan at 100 pounds per acre were intermediate. Apparently application of captan controlled some factor other than nematodes affecting growth of the plants.

Further tests in the greenhouse and in field plots are under way.

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SOME BUD MUTATIONS OF APPLE WITH VIRUS-LIKE SYMPTOMS

R. M. Gilmer and J. Einset[1]

Summary

Six fruit abnormalities of apple, four occurring in the variety Rhode Island Greening, one in the variety Northern Spy, and one in the variety McIntosh, are described. Attempts to transmit one of these abnormalities indicated that it was not of virus causation, but rather was a mutation that could be bud-perpetuated. Observational evidence indicates that the remaining five abnormalities are also bud mutations. Apple fruits resulting from such mutations are commercially worthless and develop symptoms that may easily be mistaken for those caused by certain apple virus diseases.

Bud mutations in apple are not uncommon phenomena, as is evidenced by the sizable list of such mutations compiled by Shamel and Pomeroy (8). Bud mutations in apple that lead to a change in fruit size, date of maturity, or to intensification of fruit color at harvest may occasionally prove of considerable commercial importance and, in consequence, have been discussed in some detail (3, 4, 5, 8). Undesirable bud mutations may also occur in apple (3, 4, 5, 8) but, in general, have received only cursory mention.

In recent years six fruit abnormalities in apple have been brought to our attention. Four of these abnormalities occurred in the variety Rhode Island Greening, one occurred in the variety McIntosh, while the sixth occurred in the variety Northern Spy. The purpose of this report is to describe the gross symptoms of these abnormalities and to point out the similarities of certain of them to fruit abnormalities produced by certain apple virus diseases.

DESCRIPTION OF SYMPTOMS

Greening (Heinicke A)

The tree producing abnormal fruits is at least 30 years of age. Misshapen fruits (Fig. 1) are borne on a single large branch, constituting about 20 percent of the bearing area of the tree. All fruits produced on this branch are misshapen to some degree, but some fruits are considerably more distorted than others. Affected fruits are variously reduced in size, ranging from 30 to 75 percent of normal size. Shallow indentations or furrows develop parallel to the longitudinal axis of the fruits, that is, extending from the stem end to the calyx. In the smaller fruits, the indentations are deeper and more pronounced and cracks 2 to 3 mm in depth develop through the epidermis into the underlying flesh. Heavy cork develops near and around such cracks. In many of the larger fruits with shallower indentations, cracking and corking often do not develop.

Other branches on the tree bear normal fruits. Since the disorder was first observed in 1955 it has not spread from the single affected branch into any other portion of the tree.

Symptoms of this disorder might readily be confused with those of star crack virus.

Greening (Heinicke B)

Approximately six trees were affected with this disorder. The trees were about 25 years of age and were planted in the same section of the orchard, indicating that very probably they had originated from the same lot of nursery trees. Symptoms developed on fruits of these trees were identical.

In 1951 or 1952 the owner had grafted several of the main branches in one of the trees with normal Greening. In 1953, when this tree was first observed, the grafts had united and were growing vigorously but had not yet fruited. The remainder of the tree bore misshapen

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[1]Approved by the Director as Journal Paper No. 1143, New York State Agricultural Experiment Station, Geneva, New York.

fruits that ranged in size from almost normal to less than 30 percent of normal. Longitudinal furrows developed and, as in the previous instance (Heinicke A), the furrows were indistinct or very shallow in the larger fruits but became quite deep in the smaller fruits. On many of the distorted fruits a heavy but superficial russet had developed (Fig. 2). Russet tended to be more pronounced at the calyx end of the fruits and was often, though not invariably, associated with the longitudinal furrows. An occasional small branch growing in the affected area bore fruits that were normal in size, shape, and appearance.

The tree was again examined critically in September 1958. The grafts inserted by the grower in 1951 or 1952 now comprised almost half of the bearing surface of the tree. All fruits produced on these grafts were normal, while the remainder of the tree had again produced distorted and russeted fruits, except for a few small branches which bore normal fruits.

Many of the distorted and russeted fruits closely resembled those produced on trees affected with rough skin or apple ringspot viruses.

Greening (McNicholas)

The fruit symptoms of this abnormality are distinct, although, in several respects, they resemble closely those described in Greening (Heinicke B). Fruits are variable in size, longitudinally furrowed, and russeted (Fig. 3). Development of russet is not as heavy as in the case of Greening (Heinicke B) and occurs in stripes which are closely associated with the longitudinal furrows. We have not observed the tree itself, but the distorted fruits are reliably reported to be confined to a single limb, while the remainder of the tree bears normal fruits.

Greening (Keukelaar)

The affected tree is 25 years of age or older. Misshapen fruits are borne on a single large limb, comprising about 25 percent of the bearing surface of the tree. The affected fruits again range in size from almost normal to a third of normal size and develop varying degrees of longitudinal furrowing (Fig. 4). The furrows are shallow or indistinct on the larger fruits, but become progressively deeper and more pronounced as fruit size decreases. Cracking or russeting are completely absent, but the flesh under the deeper indentations is necrotic and corky.

Fruits borne on the remainder of the tree are normal in size and appearance and, since the tree was initially observed in 1953, there has been no spread of the disorder within the tree. When observed in 1958, two branches located in the affected portion of the tree were producing normal fruits.

Symptoms on the more seriously affected fruits might be mistaken for those of green crinkle virus.

McIntosh (Tucker)

The affected tree is approximately 30 years of age. One large limb, comprising about a third of the fruiting area, bears only distorted fruits (Fig. 5). As in the previous instances described, the fruits are variable in size and develop longitudinal furrows which are more pronounced in the smaller fruits. A few of the larger fruits are merely radially asymmetrical. There is no indication of cracking or russeting on any of the fruits.

The remainder of the tree produces fruits which are normal in size and shape. The owner reports that distorted fruits have been produced on the single branch for a period of at least 25 years.

Northern Spy (Castor)

Fruits from this tree were brought to our attention in 1957, with the report that a single branch had produced distorted fruits in 1956 and 1957. Distorted fruits are about a third to half normal size, deeply furrowed, and often lobed (Fig. 6). Cracking and russet are absent. In many of the fruits development of a portion of the fruit appears to have been arrested at an early stage, while the remainder appears to have grown more or less normally, thus forming pronounced lobes or outgrowths. These lobes develop normal coloration, while the arrested segments remain a deep green in color.

The tree was visited in September 1958, but we failed to find any abnormal fruits at that

FIGURE 1. Fruits from Greening (Heinicke A). The smaller fruits show severe cracking and heavy cork development.

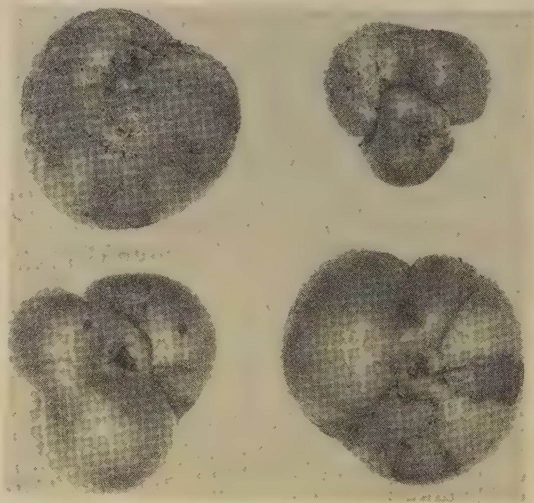

FIGURE 2. Fruits from Greening (Heinicke B). Heavy russet is superficial and does not extend into the flesh.

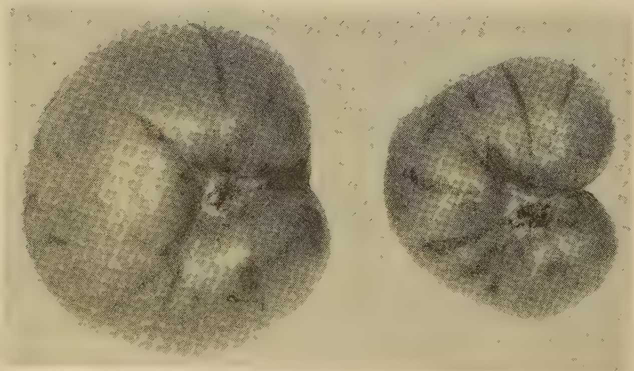

FIGURE 3. Fruits from Greening (McNicholas). Russet is not as heavy as in Fig. 2, and is closely associated with areas of indentations.

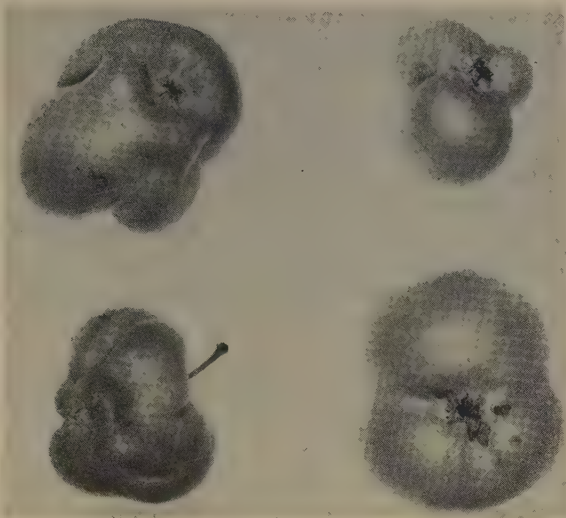

FIGURE 4. Fruits from Greening (Keukelaar). Russet is completely absent.

FIGURE 5. Fruits from McIntosh (Tucker). The longitudinal furrows are much less distinct than in the previous cases, and many of the fruits merely appear radially asymmetrical. Two of the fruits show apple scab lesions.

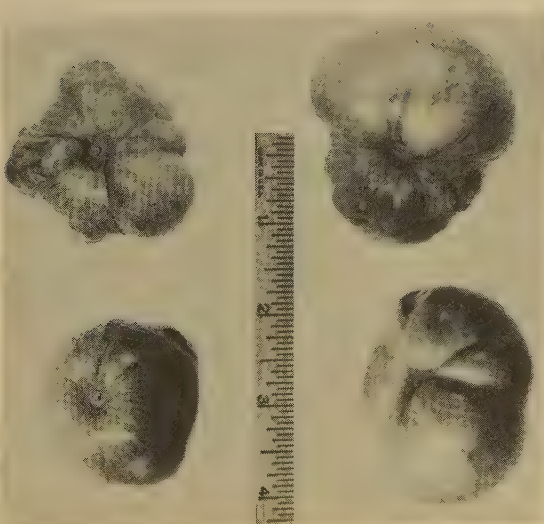

FIGURE 6. Fruits from Northern Spy (Castor). The segments showing arrested growth are still green in color, while the outgrowths have colored a normal red.

time, nor did the grower encounter any abnormally shaped fruits at harvest. It is possible that the branch that produced distorted fruits in 1956 and 1957 may have been eliminated by pruning.

EXPERIMENTATION

Only one of the six abnormalities has been extensively tested to determine whether the fruit symptoms might have developed as a result of virus infection. Buds of Greening (Keukelaar) were obtained from terminals immediately adjacent to severely affected fruits. In September 1952, yearling nursery trees of the varieties Greening, McIntosh, and Monroe were inoculated by inserting four of the affected Greening buds into each of six trees of each variety. Half of the trees thus inoculated were transplanted to 8-inch pots and removed to the greenhouse in the autumn of 1953, while the remaining inoculated trees were left in the nursery.

No foliage or growth abnormalities developed in any of the inoculated greenhouse or nursery trees. The greenhouse trees bore a few fruits in 1955 and 1956; all fruits were normal. The nursery trees fruited initially in 1956 and produced a fair crop (4 to 9 fruits per tree) in 1957. In both years all fruits were normal.

In August 1953 a group of eight seedling apple rootstocks were budded with buds of Greening (Keukelaar). Three of the trees thus propagated were transplanted to the orchard where they fruited initially in 1958. One of the trees produced only normal fruits, but the two remaining trees bore misshapen fruits identical with those on the parent Greening (Keukelaar) tree.

DISCUSSION

Green crinkle (1), apple ringspot (2), green mottle (7), and dapple apple (9), virus diseases of apple, are reported to incite symptoms only on fruits. Two other apple virus diseases, star crack (6) and rough skin (10), also incite fruit symptoms by which they are commonly diagnosed, since foliage symptoms are readily overlooked. Symptoms on apple fruits of certain of these diseases -- green crinkle, apple ringspot, star crack, and rough skin -- resemble more or less closely certain of the abnormalities described in this report. The severe cracking and corking on fruits of Greening (Heinicke A) might easily be mistaken for the similar symptoms caused by star crack virus, while the russet present in Greening (Heinicke B) and Greening (McNicholas) could be confused with symptoms of apple ringspot or rough skin. The characteristic symptoms of green crinkle (1), distorted and abnormally shaped fruits, might easily be confused with any of the six abnormalities described.

In spite of the superficial similarity of symptoms of the six abnormalities to those caused by certain viruses, observational or experimental evidence indicates that none of the six abnormalities are of virus causation. Inoculation experiments with buds of Greening (Keukelaar) gave no evidence of a virus etiology, although the fruit distortion could be perpetuated by propagating with affected buds. Transmission trials with any of the remaining five abnormalities have not been made. However, localization of the conditions to portions of the respective affected trees without spread seems to preclude a virus causation. Symptoms of the fruit abnormality of Greening (Heinicke B) did not develop over a 6-year period in healthy Greening grafts made in 1951 or 1952.

It seems obvious from this evidence that the six fruit abnormalities described in this paper are bud mutations. In the voluminous literature dealing with bud mutations or "sports" of apple, passing mention of the occurrence of russeted or abnormally-shaped fruits has occasionally been made. Shamel and Pomeroy (8) mention 26 apple mutations leading to fruit russeting, 20 mutations resulting in abnormal fruit shape, and 5 mutations resulting in long or oblong fruits. Gibson (5) figures a lobed apple fruit, described as "a sectorial size chimera composed of Giant Wealthy and Wealthy." Both Darrow et al. (3) and Gardner et al. (4) state that bud mutations resulting in "rogue" fruits (ribbed, corrugated, or radially asymmetrical) occur more frequently in such varieties as Greening than they do in other varieties.

It should be emphasized that the growth habit and the foliage of these mutants is typical of the variety from which they originated, and thus mutant branches or nursery trees cannot be distinguished from the type variety until they fruit. Accidental introduction of these mutants into commercial nurseries would prove extremely disadvantageous.

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SPREAD OF STRAWBERRY RED STELE ROOT ROT, PHYTOPHTHORA FRAGARIAE, BY RESISTANT VARIETIES AND THE SURVIVAL PERIOD OF THE ORGANISM[1]

Robert H. Fulton

Certification of strawberries for freedom from red stele root rot has been in effect in Michigan since 1937. Nursery plantings are rigorously inspected several times during the year. One or more inspections are made about blossom time or when soil and growing conditions are ideal for the manifestation of the symptoms of red stele root rot incited by Phytophthora fragariae. During late summer or fall one or more inspections are made of strawberry nurseries for other dangerous insect pests, diseases and nematodes.

SPREAD OF THE ORGANISM BY RESISTANT VARIETIES

On several occasions commercial strawberry plantings were found to be infected with red stele root rot even though certified stock had been used and these specific fields had never been cropped previously to strawberry. In 1952, observations by State inspectors disclosed a possible explanation. While checking a nursery planting of the red stele resistant variety Sparkle they noted that an adjoining commercial strawberry field was infected. Most of the sites of the red stele infection were located on the side of the field that adjoined the nursery planting. Also, the nursery was located on higher ground so that drainage was through the established field. Finally, certified stock had been used to plant the commercial field and no past history of red stele was recorded for either planting.

This information was forwarded so that a study could be initiated to determine if red stele resistant strawberry varieties could be carriers of Phytophthora fragariae. In December, plants of three red stele resistant varieties, namely, Fairland, Sparkle and Temple, were obtained from nursery sites known to be contaminated with the causal organism. These plants were dug at random and then packed for shipment, in the same manner used in commercial nursery practice for grower use.

Twelve plants of each resistant variety, after being carefully checked for any signs of the disease, were individually potted in steam-sterilized soil along with a plant of the susceptible variety Robinson. A source of healthy Robinson stock was obtained by setting runner stolons over into steam-sterilized soil to alleviate any possibility of incipient red stele root rot infection. The three lots of plants were first allowed to become established and then were transferred to a greenhouse room maintained at 55°F during the winter months. The pots were watered regularly so as to maintain a high soil moisture content.

Periodically the plants were checked for any of the foliar symptoms of wilting or lead blue leaf coloration common for red stele. However, none of the plants showed any visible aerial symptoms of the disease. In April, all plants were carefully removed from the pots, cleaned in running tap water, the roots split longitudinally and examined for signs of infection. The results of this test are presented in Table 1.

As indicated in Table 1 red stele root rot was transmitted to the susceptible variety Robinson by all three varieties under test. It is apparent, even though the plants were dug at random throughout the nursery field, that the variety Sparkle may be responsible for the major spread of Phytophthora fragariae into clean commercial field soils.

Since the resistant varieties were grown on contaminated soil and the plants were dug and cleaned in the regular nursery practice common for grower use, it is possible that the infection could have occurred through soil particles on the transplants. On the other hand, transmission in lightly infected roots is also possible. No seedling or variety has been found completely immune in breeding trials where infection was rated on a scale of 0 to 10. Thus it is not at all improbable that the causal organism could be spread in this manner.

[1] Journal Paper No. 2361, Michigan Agricultural Experiment Station; Journal Article No. 58-37, Department of Botany and Plant Pathology.

Table 1. The role of red stele resistant varieties on the spread of Phytophthora fragariae.

Variety		Resistant	Red Stele Infection: Roots[a] (number)	Red Stele Infection: Plants[b] (number)
I.	Fairland	Yes	0	0
	Robinson	No	68	7
II.	Sparkle	Yes	0	0
	Robinson	No	111	10
III.	Temple	Yes	0	0
	Robinson	No	52	5

[a] 25 roots and/or rootlets per plant were examined.
[b] 12 plants per variety.

SURVIVAL PERIOD OF THE ORGANISM

Yearly records of strawberry nursery inspections as to location and varieties are kept on file by the Michigan Department of Agriculture, Division of Plant Industry. Through these records it was possible to trace the longevity of Phytophthora fragariae in the soil of certain 1-year-old strawberry fields. Infection was noted in Hillsdale loam soils varying in periods of rotation from 4 to 13 years. In most instances the fields had been cropped to cereals or legumes in the intervening years between strawberry crops. The field with the 13 year survival period had been cropped to wheat, oats and rye for 10 years (no available record of rotation), Sudan grass the eleventh year, then planted to strawberry the following spring. Red stele infections were noted the next spring, scattered throughout the field. To further corroborate this finding the mother bed of the planting stock was re-inspected and found to be free of the causal organism.

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WALNUT BLAST, A NEW BACTERIAL DISEASE OF WALNUT

Peter A. Ark[1] and Milton R. Bell[2]

Abstract

A disease on Juglans mandchurica, caused by a bacterium closely resembling Pseudomonas syringae, was observed in epidemic form from 1955 to 1958 in experimental trees grown in Berkeley, California. The organism produces a blasting of the nutlets and various degrees of spotting on the leaves. It was also found on English walnuts on both the nutlets and the leaves. Lesions were produced in lemons, young plum, peach, and almond fruit and in green rose hips, as well as on young cowpea leaves, by needle inoculations and by spraying (cowpeas and almonds) with the isolates from both J. mandchurica and English walnut. These lesions were identical with those induced by authentic cultures of P. syringae isolated from black pit of lemons, almond blast, and bacterial gummosis of plums.

The two known bacterial diseases on walnuts include walnut blight, caused by Xanthomonas juglandis and a recently reported[3] bark canker, caused by Erwinia nigrifluens.

In the spring of 1955 the senior author observed blasting of the nutlets and leaf spotting on experimental trees of Juglans mandchurica grown in experimental plots at Berkeley, California. The disease increased in the following season and in 1957 it appeared in destructive form, causing complete loss of the walnut crop on 12-year-old trees and conspicuous spotting of the leaves. Many vegetative buds were killed by the disease.

In general appearance the disease resembled walnut blight except that both the killed nutlets and the leaf spots were somewhat blacker and drier in external appearance than those affected by walnut blight (Figs. 1, 2). The affected nutlets dropped prematurely. Heavily infected leaves also dropped prematurely.

Cultures from the nutlets and the leaf spots yielded grayish-white bacterial colonies on potato-dextrose-peptone or beef extract-peptone nutrient agar plates. No yellow colonies typical of the walnut blight organism, Xanthomonas juglandis, were observed on agar plates from nutlets or leaves collected from Juglans mandchurica.

PATHOGENICITY TESTS

Numerous isolates from the nutlets and the leaves of diseased J. mandchurica were tested on greenhouse-grown seedlings of black and English walnuts. A suspension of bacteria in sterile distilled water made from a 24-hour-old agar slant growth of the organism was sprayed on the walnut seedlings and the inoculated plants were incubated overnight in a moist chamber at temperatures between 75° and 80° F. After this the inoculated plants were placed on a greenhouse bench where the temperature was maintained at 75° to 80° and humidity fluctuated between 70 and 80 percent. The first symptoms of the disease appeared on the leaves after 3 days, as minute water-soaked black spots which enlarged to a size of 2 to 4 mm within the next 4 or 5 days (Figs. 3, 4). Conspicuous yellow zones appeared around the points of infection. Bean plants (Bountiful and Black Velvet varieties) and young cowpeas sprayed with the isolates from Juglans mandchurica showed very conspicuous black leaf lesions surrounded by very pronounced yellow zones. Young tomato seedlings sprayed with a young culture of the organism were heavily infected and the tips of the sprayed plants died back within a few days. Young fruits of apricot, plum, almond, rose (hips) and lemon showed large black spots as a result of needle inoculations. Almond and peach seedlings sprayed with the isolates from

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[3] Wilson, E. E., Mortimer P. Starr, and Joyce A. Berger. 1957. Bark canker, a bacterial disease of the Persian walnut tree. Phytopathology 47: 669-673.

FIGURE 1. Symptoms of a walnut blast on leaves of Juglans mandchurica. Natural infections. Note yellow zones around the spots and a ragged appearance of the margins of the leaflets resulting from heavy infection.

FIGURE 2. Leaflets from a compound leaf of Juglans mandchurica naturally infected with walnut blast organism.

FIGURE 3. Abundant leaf spots on an English walnut seedling grown in a greenhouse and sprayed with a bacterium isolated from a leaf spot on a leaf of Juglans mandchurica. Greenhouse experiment.

FIGURE 4. Leaf spots on English walnut seedling produced by spraying with a bacterial suspension of a walnut blast organism isolated from the blasted nutlets of Juglans mandchurica. Greenhouse experiment.

J. mandchurica developed considerable spotting and when needle-inoculated near the tips showed die-back of several inches from the point of inoculation. In all cases reisolation of the original organism was successful.

Cultures of *Pseudomonas syringae* isolated from citrus, almond, and plum blast were included in the inoculation tests. There was no apparent difference in the symptoms produced by *P. syringae* and the isolates from *J. mandchurica*. Preliminary bacteriological tests to determine morphological characteristics and reactions in sugar and other media showed a close similarity between *P. syringae* and the isolates from *J. mandchurica*.

In 1956 walnut leaves and nutlets of Payne walnut trees from Glenn County showing symptoms atypical of blight were collected for bacteriological examination. Both streak and dilution plates from the lesions made on potato-dextrose agar media revealed the presence of *Xanthomonas juglandis* and grayish-white colonies resembling the isolates from *J. mandchurica*. Occasionally no admixture of *X. juglandis* was observed. Cultural tests and inoculation tests with the various hosts mentioned above showed that the grayish-white organism from Glenn County was identical with *P. syringae* and the organism from *J. mandchurica*.

In the summer of 1958 numerous collections of spotted leaves and very small blackened nutlets from Payne walnut trees grown in Contra Costa County were made by the junior author. It should be said that the drop of nutlets in walnut orchards in Contra Costa County was unusually heavy in the early summer of 1958. This raised the question of the existence of other factors in addition to walnut blight as causes of premature dropping of nutlets. Cultures of numerous leaf and nutlet lesions yielded mixed cultures of *Xanthomonas juglandis* and *P. syringae*. The latter were identical with the isolates of previous years from *Juglans mandchurica* and the Payne walnuts from Glenn County.

CONCLUSION

It is believed that this is the first report of a bacterial disease of *Juglans mandchurica* and English walnut caused by *Pseudomonas syringae*, the organism which causes blast of citrus and stone fruits. In English walnuts (Payne var.) the blast-producing organism was found singly and in association with *Xanthomonas juglandis*, the cause of walnut blight.

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CONTROL OF CERTAIN DISEASES OF PLANTS WITH ANTIBIOTICS FROM GARLIC (ALLIUM SATIVUM L.)

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Abstract

The juice of garlic cloves (*Allium sativum* L.) and aqueous as well as certain organic solvent extracts of commercial garlic powder possess strongly bactericidal and fungicidal properties. Both Gram positive and Gram negative plant pathogens are sensitive to garlic extracts in varying degrees. The volatile component of garlic preparations is equally toxic to plant pathogenic micro-organisms. Downy mildew of cucumber, downy mildew of radish, cucumber scab, bean rust, bean anthracnose, early blight of tomato, brown rot of stone fruits, angular leaf spot of cucumber, and bacterial blight of beans were effectively controlled by sprays of 1 to 20 percent aqueous extracts of garlic powder preparations. Downy mildew of cucumber and bean rust were controlled by a dust formulation of garlic powder in pyrophyllite carrier. The objectionable odor of garlic in sprays was completely neutralized by water-soluble neutroleum. Garlic powder preserved its antibiotic property for 3 years, when stored at room temperature in a closed cardboard container.

The antibiotics derived from saprophytic microorganisms, chiefly from various Actinomyces, are at the present time recommended against bacterial and fungus pathogens of plants (1, 10). However, because of antibiotic residue problems, such materials are subject to a strict surveillance by governmental agencies and, hence, their use may be viewed as somewhat limited in plant pathology. Therefore, antimicrobial agents originating from higher plants, especially from those that have been used as food by human beings throughout the long history of mankind, deserve attention and careful scientific investigation. The search for such substances is already in progress, as indicated by contributions from different parts of the world (5, 6, 7, 8, 9). Several papers dealing with the antimicrobial properties of garlic have appeared in the scientific literature (2, 3, 4).

The present paper reports results obtained on the effect of garlic juice and aqueous extracts from the preparations of commercial garlic, *Allium sativum*, on various plant pathogens *in vitro* and the experimental control of plant diseases with crude garlic preparations.

MATERIALS AND METHODS

The toxicity of garlic to microorganisms was determined by expressing the juice from the garlic cloves, saturating antibiotic assay filter paper discs (S&S, #740E), drying the discs at 40° C for 60 minutes and placing the discs on nutrient agar plates each seeded with one of the following test organisms: *Erwinia amylovora*, *E. carotovora*, *Pseudomonas syringae*, *P. phaseolicola*, *P. lachrymans*, *Xanthomonas vesicatoria*, *X. juglandis*, *Corynebacterium michiganense*, *Agrobacterium tumefaciens*, *Monilinia fructicola*, *Botrytis allii*, *Gloeosporium cingulatum*, *Cladosporium cucumerinum*, and *Colletotrichum lindemuthianum*. Obligate parasites, such as *Pseudoperonospora cubensis*, *Peronospora parasitica*, *Puccinia graminis*, and *Uromyces phaseoli*, were tested for germination of their spores in the extract of garlic powder, as well as on plant surfaces sprayed or dusted with garlic formulations.

To seed the test plates, suspensions of both the bacteria and fungus spores were made to a certain standard turbidity by use of the Klett-Summerson colorimeter and poured into the agar plates. Excess suspension was removed from each plate by means of a sterile pipette and

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the surfaces of the plates were dried for 20 minutes at 40° C before the discs were placed on them. All plates were incubated at 28° C for 24 or 48 hours prior to reading the inhibition zones with the antibiotic zone reader.

The experimental plants grown in a warm greenhouse consisted of: beans (Pinto, Bountiful, and Blue Velvet varieties), cucumber (Marketer var.), radish, spinach, almonds, cherries, and apricots. This work reports only the preventive action of garlic preparations in which the plants were sprayed with the pathogenic organisms followed by applications of the garlic or vice versa. Inoculated plants were incubated for 24 hours in a highly humidified moist chamber and subsequently transferred to benches for a period of time before a final reading of the results.

Antibiotic Action of Garlic in Vitro

All test bacteria and fungi were susceptible in varying degrees to the action of pure undiluted garlic juice derived directly from the cloves, and to the aqueous extracts of a commercial powdered garlic. However, Agrobacterium tumefaciens was less affected by the aqueous extract of garlic than were either Erwinia amylovora or Xanthomonas vesicatoria (Fig. 1) and Xanthomonas vesicatoria was more sensitive to straight garlic juice than was Pseudomonas syringae (Fig. 2). From the experimental tests it is evident that garlic contains a volatile fraction that is quite toxic to both the bacteria and the fungi. The potencies of preparations obtained with organic solvents varied with different microorganisms (Table 1.) The downy mildews, rusts and facultative fungi were strongly affected by the garlic extracts (Table 2).

Table 1. Inhibition zones in mm -dia. produced by various extracts of a garlic powder on plates of two bacterial and two fungus plant pathogens. Disc diameter = 12.7 mm.

Extractant	Fungi		Bacteria	
	Glomerella cingulata	Cladosporium cucumerinum	Erwinia amylovora	Xanthomonas vesicatoria
Chloroform	32	45	23	40
Ether	16	22	0	0
Diethylene glycol	0	0	17	32
Triethylene glycol	0	0	17	31
70 percent Ethyl alcohol	39	55	30	38
90 percent Ethyl alcohol	0	0	0	0
99.5 percent Methyl alcohol	0	0	0	0
Distilled water	55	55	42	47

Table 2. Effect of different concentrations of aqueous extracts of garlic powder on spore germination of downy mildew of cucumber, cucumber scab, bean rust, and Glomerella cingulata, expressed as percentage.

Germinating medium	Pseudoperonospora cubensis	Cladosporium cucumerinum	Uromyces phaseoli	Glomerella cingulata
Check. Distilled water	53	70	18	91
1 percent aq. garlic extract	.25	0	0	0
2 percent " " "	.10	0	0	0
5 percent " " "	0	0	0	0
10 percent " " "	0	0	0	0
20 percent " " "	0	0	0	0

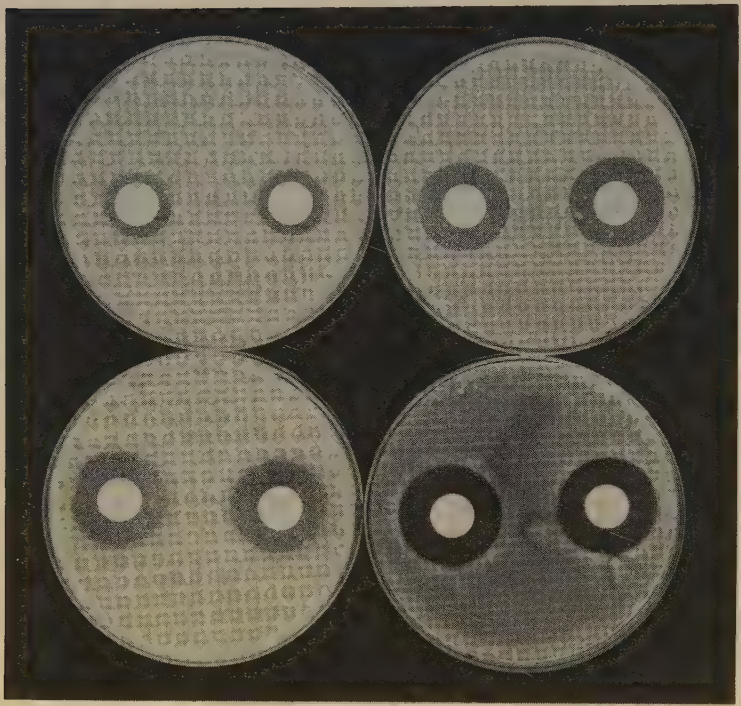

FIGURE 1. Cleared zones show effect of lyophilized garlic juice (10%) in the paper discs on: upper row--Agrobacterium tumefaciens (left), and Xanthomonas vesicatoria (right); lower row--Corynebacterium michiganense (left), and Erwinia amylovora (right).

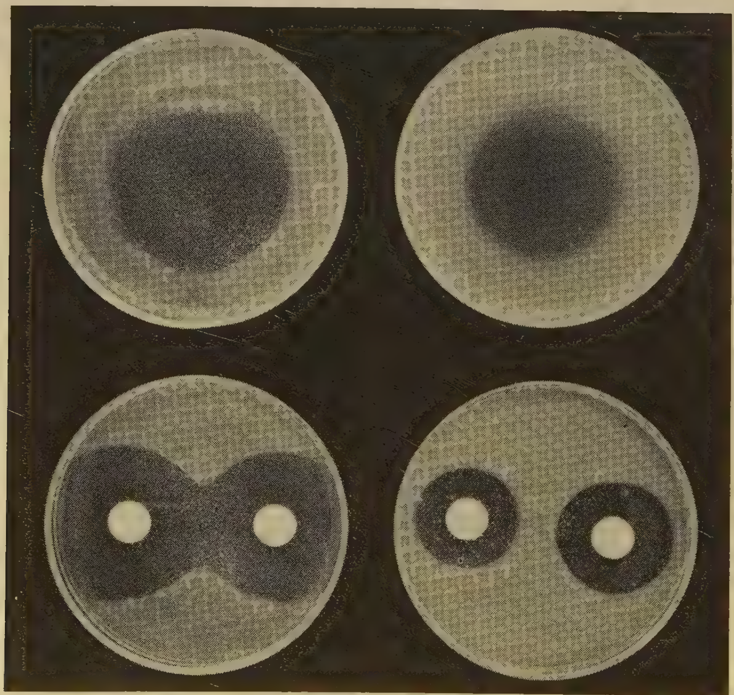

FIGURE 2. Effect of garlic juice (expressed from bulb and diluted with water, 1:1), lower row, and garlic vapor, upper row, on Xanthomonas vesicatoria, left, and Pseudomonas syringae, right. Lower row shows clear zones around filter paper discs impregnated with garlic extract. Upper row shows large clear zones produced by garlic vapor that emanated from a paper disc saturated with garlic juice and placed on the inside of a lid opposite the surface growth; the plates incubated in inverted position and the cracks were sealed with a plasticine.

Antibiotic Action of Garlic in Vivo

Control of Downy Mildews: Cucumber plants in a 3- or 4-leaf stage were sprayed with the conidia of *Pseudoperonospora cubensis* and placed in a high humidity moist chamber for 24 hours, after which they were held on a greenhouse bench at a temperature of 75° to 80° F and under high humidity. The results were read after 7 days (Table 3). Spraying with 10 and 20 percent aqueous extracts of a commercial garlic powder and dusting with 50 percent garlic powder in Cellite 500 or Nuclay pyrophyllite against radish and spinach downy mildews gave perfect control.

Table 3. Control of plant diseases by spraying with garlic extracts. Infections expressed as number of lesions per leaf or leaflet.

Fungus or bacterium	Disease	Check	Aqueous garlic extracts (percent) 1	2	5	10	20
Pseudoperonospora cubensis	Downy mildew	33.0	0	0	0	0	0
Uromyces phaseoli	Bean rust	162.0	0	0	0	0	0
Alternaria solani	Early blight of tomato	24.1[a]	-	-	-	-	.29[a]
Cladosporium cucumerinum	Cucumber scab	100.0[b]	-	-	-	0	0
Pseudomonas phaseolicola	Bean blight	84.6	-	-	2.5	1.7	0
Pseudomonas lachrymans	Angular leaf spot of cucumber	160.0	-	-	-	33.0	58.5

[a]per leaflet
[b]plants

Control of Cucumber Scab (*Cladosporium cucumerinum*): Very young plants of cucumbers (Marketer var.) were used for the test. The plants were treated as described above for the downy mildews. Reading could usually be made after 3 or 4 days. Aqueous garlic extracts of the 2 and 10 percent strengths gave an excellent control of the disease.

Control of Bean Anthracnose (*Colletotrichum lindemuthianum*): For this test Bountiful, Black Velvet, and Pinto beans were used. On Bountiful bean, the anthracnose fungus causes a very severe blighting and general collapse of the plant, while in Black Velvet and Pinto beans the injury is usually less severe, resulting only in local lesions in the latter variety. Complete protection against the disease was obtained by one spraying with a 10 or 20 percent aqueous garlic powder extract (Fig. 3).

Brown Rot of Stone Fruits (*Monilinia fructicola*): Both volatile and nonvolatile fractions of the garlic were tested against brown rot on peach fruit and pot-grown almond and apricot plants. Freshly picked fruit free of apparent injuries were submerged for 5 minutes in a 20 percent aqueous extract of powdered garlic, removed to previously sterilized moist glass chambers, air dried and then inoculated by dropping a heavy conidial suspension into a suture (unwounded) as described in earlier experiments (Fig. 4), incubating at room temperature. Appropriate checks were provided. In the second series of the experiment the peach fruits were placed in sterilized inverted moist chambers and after inoculation, but before closing the chambers, a paper towel wetted in 20 percent aqueous garlic material was used to line the inside side wall of the chambers in such a way as not to touch any fruit. The cracks between the lid and the bottom part of the chamber were sealed with plasticine. The set was incubated at room temperature. The potted plants were sprayed with garlic extract as previously described for the cucumbers, inoculated and incubated in special moist chambers where the humidity approached almost 100 percent. The tests indicated a complete control of brown rot, *Monilinia fructicola*, with 5, 10 and 20 percent garlic extracts (Figs. 4 and 5).

Control of Bacterial Diseases: Bean and cucumber plants were sprayed with *Pseudomonas phaseolicola* and *P. lachrymans*, respectively, and then sprayed with aqueous 10 and 20 percent powdered garlic extracts. A good control of the respective diseases was obtained (Table 3).

FIGURE 3. Control of bean anthracnose, caused by Colletotrichum lindemuthianum, with aqueous extract of garlic powder. 1 -- Check. A Bountiful bean plant sprayed with fungus spores, incubated overnight in moist chamber and placed on greenhouse bench for 5 days. 2 -- A Bountiful bean plant sprayed with 10 percent aqueous extract of garlic powder, air dried, sprayed with fungus spores and handled as in 1. No infection visible.

DISCUSSION

These experiments indicate the possibility of controlling such diseases as downy mildew of cucumber, bean anthracnose, brown rot of stone fruits, cucumber scab, and certain bacterial diseases of bean and cucumber with sprays containing aqueous extracts of powdered garlic as well as with the juice directly from the cloves. Experiments on utilization of lyophilized aqueous extracts of garlic were also successful. This lyophilized material is very dispersible in water and makes a stable opalescent solution. The objectionable pungent odor of garlic can be neutralized by an alpha neutroleum, providing a very pleasantly aromatic and cheap preparation. Garlic powder retains its full activity for at least 3 years when kept dry.

SUMMARY AND CONCLUSION

1. Garlic juice and aqueous and organic solvent extracts of garlic exhibit antibacterial and antifungal properties in vitro and on leaves and fruit.

2. Aqueous extracts of a commercial garlic powder, when applied as sprays or dusts, protected cucumbers against downy mildew (Pseudoperonospora cubensis), cucumber scab (Cladosporium cucumerinum) and angular leaf spot (Pseudomonas lachrymans). Bean plants were protected against bean anthracnose (Colletotrichum lindemuthianum) and a bacterial blight

FIGURE 4. Action of aqueous powdered garlic extract on brown rot of peach. 1 -- Check. Four fruits dipped in water, air dried and spores placed in unwounded depression at the tip. Heavy infection. 2 -- Four fruits dipped in 20 percent garlic extract, air dried and inoculated as in check. 3 -- Four fruits inoculated as in 1 and held in moist chamber saturated with garlic vapor.

FIGURE 5. Control of brown rot of stone fruits, Monilinia fructicola, by aqueous garlic extract. 1 -- Check. Apricot seedling sprayed with fungus spores and incubated in moist chamber for 4 days; shows heavy infection. 2 -- Apricot seedling sprayed with 10 percent aqueous extract of garlic powder, air dried, then sprayed with fungus spores and handled as in 1.

(Pseudomonas phaseolicola). Peach fruit and potted almond and apricot plants were protected from brown rot (Monilinia fructicola) by sprays and dusts containing garlic extracts.

3. The volatile fraction of garlic appears to be very bactericidal and fungicidal for many plant pathogenic microorganisms.

4. Garlic powder did not lose its antibiotic properties for 3 years.

5. The objectionable garlic odor can be successfully and completely denatured by a water soluble alpha neutroleum, a product of the Fritzche Bros., New York, N.Y.

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SOIL TREATMENTS FOR CONTROL OF SCLEROTIUM ROLFSII IN DUTCH IRIS

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Summary

Row treatments with Terraclor were found to be adequate in reducing the incidence of Sclerotium rolfsii and increasing yields of bulbs and flowers only in certain seasons. When conditions were highly favorable for disease development, only the broadcast rates were consistently effective but rates as low as ~~75~~ pounds per acre of pentachloronitrobenzene gave good control. Soil fumigation with Vapam at 100 and 150 gallons per acre caused phytotoxicity as did N-521 at 430 and 650 pounds per acre. Vapam at 25 and 50 gallons per acre reduced disease intensity somewhat but did not increase yields. 100 - see [illegible]

INTRODUCTION

Sclerotium rolfsii is a serious pathogen on a wide range of crops in all of the warmer regions of the world (7). It is particularly important as a cause of crown and stem rot of Dutch iris in southeastern North Carolina (5) where temperature and moisture conditions are ideal for fungus development in late spring and summer. Heavy losses of bulbs occur in both field and storage.

The fungus attacks the growing plant at or about ground level. The bulbs are attacked through the invaded stem or infested roots. The leaves turn yellow and under warm moist conditions the base of the stem and surrounding area become covered with the characteristic white mold and tan to reddish brown sclerotia (3). Under field conditions in North Carolina flowers are harvested considerably in advance of the appearance of the disease; however, stems of flowers that are left in the field remain erect even when the plant is killed by Sclerotium rolfsii because the woody structure of the stem is not destroyed. Infected bulbs show a soft cheesy rot (3) and a mass of soil often clings to them at harvest. Mycelia and sclerotia are found in the adhering soil. Bulbs if not completely rooted when dug may continue to decay in storage.

Control measures in North Carolina have been restricted to crop rotation and early harvest of bulbs. The latter practice, however, has resulted in lower yields and some sacrifice in bulb quality according to Haasis (5). He showed experimentally in 1954 that disease incidence was decreased in soils fumigated with chlorobromopropene, but yields of bulbs were not significantly increased. When non-treated bulbs were planted in fumigated soils survival and yield were significantly lower than that of non-treated bulbs planted in non-treated soil. Haasis postulated that reduction of antagonistic organisms in fumigated soil permitted a build-up of the basal rot organism (probably Fusarium oxysporum Schlecht.) carried on non-treated bulbs. Gould (4) found that chlorobromopropene and DD increased losses from crown rot in Washington because antagonistic organisms were thought to be eliminated. Of numerous materials tried experimentally for the control of crown rot under both greenhouse and field conditions Gould reported that pentachloronitrobenzene at 200 to 300 pounds per acre of active material appeared most promising. He reported that the cost of this material was the chief drawback to its general use.

Because of a real need for some effective and economical measure for controlling crown rot in Dutch iris in southeastern North Carolina, field experiments were initiated in 1955 and continued through 1958 in which a number of soil fumigants and fungicides were compared. These results are reported here.

MATERIALS AND METHODS

Size of plots were usually 15 feet x 6 feet and were replicated four times. Plantings were made each fall in soil where a cover crop of soybeans had been turned under several weeks beforehand so that conditions would be favorable for the development of Sclerotium rolfsii (1).

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Vapam and N-521 were applied at the various rates in 2-3000 gallons of water per acre and subsequently sealed in with approximately the same amount of water. In other broadcast treatments the fungicides were dusted or drenched onto the soil in a small amount of water and were then rototilled in. Where row treatments were applied at planting time the materials were dusted into the furrow before the bulbs were covered. Row treatments with Terraclor in the spring were applied by drenching onto the bed in 1 foot bands, 6 inches on either side of the row. Applications of 6 pounds each of pentachloronitrobenzene were applied three times at 2-week intervals beginning in mid-April.

Two varieties of Dutch iris, Wedgewood and Imperator (size 6 to 7 cm), were used in separate series of soil treatment experiments. All plots were split with one-half of each planted to native bulbs and one-half to bulbs imported from Holland. Plantings were made in October of 1955, 1956, and 1957, allowing a minimum of 2 weeks to elapse between soil treatment and planting. Bulbs were harvested in each succeeding June, treated with Dowicide B (2 pounds per 100 gallons water for 15 minutes) and stored during the summer months. They were cleaned and examined in September. Records were kept during each season of number and grade of flowers produced, number and weight of bulbs and bulblets harvested and disease incidence in the field.

EXPERIMENTAL RESULTS

Severe phytotoxicity resulted from the use of Vapam at 100 and 150 gallons per acre. The two higher rates of N-521 also caused injury. The primary effect of phytotoxicity was failure of the bulbs to root properly which resulted in delayed and reduced emergence. Flower production was also significantly reduced in these plots the first season (Table 1) in contrast to flower yields in other plots which were unaffected during the first season.

Table 1. The effect of soil treatments on yield of Imperator Dutch iris bulbs and flowers.

Treatment[a]	Yield[b]: Weight of bulbs and bulblets (in grams)			Number of flowers		
	1956	1957	1958	1956	1957	1958
Vapam, 50 gallons/acre	390	418	390	44.5	20.2	29.5
Vapam, 100 gallons/acre[c]	359	-	-	34.5	--	--
Vapam, 150 gallons/acre[c]	273	-	-	25.3	--	--
N-521, 215 pounds/acre[c]	359	-	-	39.1	--	--
N-521, 430 pounds/acre[c]	308	-	-	26.8	--	--
N-521, 650 pounds/acre[c]	152	-	-	9.5	--	--
Terraclor 75%, 24 pounds/acre (Row)[b]	521*	463	321	42.7	20.1	33.7
Terraclor 75%, 100 pounds/acre	518*	735*	700*	48.8	25.5*	52.5*
Terraclor 75%, 133 pounds/acre	460	753*	631*	46.2	22.6*	48.0*
Terraclor 75%, 200 pounds/acre	473	663*	723*	47.1	21.8*	50.3*
Terraclor 75%, 33 pounds/acre (Furrow)[c]	527*	603	349	47.1	23.0*	42.0
Captan, 87 pounds/acre	517*	451	278	47.1	19.7	33.4
Zineb, 25 pounds/acre[c]	416	532	392	46.8	18.5	40.1
Control	390	517	351	48.7	17.6	34.7
LSD (.05)	87	127	221	9.8	3.3	14.0
LSD (.01)	116	N. S.	299	14.2	4.4	N. S.

[a]See Materials and Methods section for methods of application. Active ingredient and source of materials are: Vapam, 31% sodium methyl dithiocarbamate (anhydrous), Stauffer Chemical Company; N-521, 90% 3,5-dimethyltetrahydro-1,3,5 2H thiadiazine-2-thione, Carbide and Carbon Chemicals Company; Terraclor, 75% pentachloronitrobenzene, Olin Mathieson Chemical Corporation; Captan, 50% N-(trichloromethylthio)-4-cyclohexene-1,2 dicarboximide, California Spray-Chemical Corporation; zineb, 65% zinc ethylenebis (dithiocarbamate), Rohm and Haas Company.

[b]Mean yields from locally grown and imported (Holland) bulbs.

[c]Tested only one season.

*Significantly greater than control.

Table 2. The effect of soil treatments on yield and disease incidence (Sclerotium rolfsii) in Wedgewood Dutch iris bulbs.

Treatment[a]	Yield: Bulbs and bulblets 1957 (grams)	Yield: Bulbs and bulblets 1958 (grams)	Yield: Number flowers 1958	Disease incidence[b] 1957
Vapam, 25 gallons/acre	453.1	562.6	19.4	21.8*
Vapam, 50 gallons/acre	465.5	668.7	31.8	14.5*
Terraclor 75%, 24 pounds/acre (Row)	499.5	731.2	35.1	16.2*
Terraclor 75%, 100 pounds/acre	589.2*	1138.1*	39.6*	9.2*
Terraclor 75%, 133 pounds/acre	602.7*	1026.5*	39.0*	9.5*
Terraclor 75%, 200 pounds/acre	594.1*	1150.2*	42.4*	6.0*
Terraclor 75%, 33 pounds/acre (Furrow)	484.8	690.5	29.9	23.5*
Captan, 87 pounds/acre	519.1	632.4	34.2	30.0
Control	462.1	567.5	31.8	30.5
LSD (.05)	88.1	257.4	6.5	3.8
LSD (.01)	119.1	347.7	8.8	5.1

[a]See Materials and Methods section for method of application and Table 1 for source and composition of materials.
[b]Number stems showing signs of S. rolfsii.
*Significantly greater than control.

Table 3. The effect of source of bulbs and soil treatment on yield of Imperator Dutch iris.

Source of bulbs Treatment[a]	Yield of bulbs and bulblets (in grams)[b] Native	Imported
Vapam, 50 gallons/acre	358	422
Vapam, 100 gallons/acre	278	440
Vapam, 150 gallons/acre	174	373
N-521, 215 pounds/acre	248	470
N-521, 430 pounds/acre	247	369
N-521, 650 pounds/acre	80	223
Terraclor 75%, 24 pounds/acre[b]	406	637*
Terraclor 75%, 100 pounds/acre	405	630*
Terraclor 75%, 133 pounds/acre	324	595*
Terraclor 75%, 200 pounds/acre	378	568*
Terraclor 75%, 33 pounds/acre[b]	437*	617*
Captan, 87 pounds/acre	402	632*
Zineb, 87 pounds/acre	310	521
Control	333	446
LSD (.05)	88	88
LSD (.01)	117	117

[a]See Materials and Methods section for methods of application and Table 1 for source and composition of materials.
[b]Mean yields from locally grown and imported (Holland) bulbs.
*Significantly greater than control.

The outstanding treatments for all 3 years were those in which Terraclor was applied as broadcast treatments (Tables 1, 2). Nevertheless in 1956 (Table 1) row treatments using Terraclor 75%, either as a drench alongside the base of plants at 24 pounds per acre or applying the material at 33 pounds per acre in the furrow at planting time, resulted in yields equal or superior to the broadcast treatments. In 1957 and 1958, however, when conditions were much more favorable for the development of Sclerotium rolfsii similar row treatments checked the incidence of disease but did not result in increased yields. Broadcast applications of as little as 100 pounds per acre were consistently as good as higher rates in reducing disease incidence and increasing yields. Captan at 87 pounds per acre resulted in good disease control in only one season. Vapam at 50 gallons per acre reduced incidence of disease in 1957 but did not result in significantly increased yields of flowers or bulbs.

The data in Tables 1 and 2 represent the mean for all bulbs planted in each soil treatment; that is, yields from sub-plots which were planted with bulbs from the two sources are averaged. The imported bulbs planted in 1955 resulted in more vigorous plants and higher yields than did locally grown bulbs. Although soil treatments with Terraclor resulted in greater average yields than with the control, a significant interaction occurred in 1956 between source of bulbs and soil treatment. In Table 3 are shown the yields for both native and imported bulbs. For some reason only the row treatment at 33 pounds per acre of Terraclor significantly increased yield where locally grown bulbs were planted. On the other hand all of the Terraclor treatments, as well as Captan, resulted in increased yields in sub-plots planted to imported bulbs. The presence of Fusarium basal rot in the native bulbs is thought to have been partly responsible for the two different responses, particularly since Terraclor is not effective against Fusarium. It is also possible that the degree of phytoxicity of certain treatments was affected by bulb source.

DISCUSSION

The use of Terraclor has been demonstrated by others (2, 4) to be effective against Sclerotium rolfsii and the results reported here support those of Gould (4) but suggest further that lower rates are adequate for control of the disease in Dutch iris in North Carolina. Satisfactory control has been obtained in some cases by combining a furrow application (33 pounds per acre) with row treatments applied just prior to the appearance of the disease in the spring.

These results were obtained when bulbs were left in the ground for a single season. It is a common practice of growers in southeastern North Carolina to leave bulbs in the field under certain conditions for 2 years. In such cases it is not likely that broadcast applications at time of planting would be adequate for disease control during two seasons. Additional row applications during the second year would perhaps be necessary.

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BRIEF NOTES ON PLANT DISEASE OCCURRENCE

BROWN SPOT OF SOYBEANS IN NEW JERSEY

By R. A. Cappellini

Brown spot of soybeans, caused by Septoria glycines Hemmi, was found abundantly on plants in several fields entered for certification in central and southern New Jersey in September, 1958. Leaves of infected plants of Hawkeye and Clark varieties showed numerous lesions and typical light-brown pycnidia and spores as described by Johnson, Chamberlain and Lehman[1]. According to these authors the fungus is seed-borne, and seed treatment does not give satisfactory control of the disease. Approximately 10 percent of the total soybean acreage entered for certification was rejected. The late occurrence of the disease had no apparent effect on yield.

This appears to be the first report of brown spot on soybeans in New Jersey.

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[1]Johnson, H. W., D. W. Chamberlain, and S. G. Lehman. 1954. Diseases of soybeans and methods of control. U. S. D. A. Cir. 931: 9-10.

AN EARLY RECORD OF PEAR RUST IN ARIZONA[1]

By Paul D. Keener

A species of Gymnosporangium attacking quince, pear and hawthorn in Arizona was reported previously (PDR 37: 235, Apr. 15, 1953. Fig. 2). Fruits as well as leaves of these hosts were infected.

An earlier collection of apparently the same species of rust on fruits of Pyrus communis was found among several rust specimens recently sent to this Department from the herbarium of the United States Department of Agriculture, Forest Service, Forest Insect and Disease Laboratory, Albuquerque, New Mexico. As in the 1953 material, infected fruits were quite deformed and unfit for consumption (Fig. 1).

FIGURE 1. Roesteliae of a species of Gymnosporangium on fruits of pear, variety Winter Nelis.

The structures represented in Figure 1 are roesteliae of the Gymnosporangium on pear fruits of the variety Winter Nelis. The collection was made by Ralph Roland, at Prescott, Yavapai County, on October 6, 1917.

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[1]Arizona Agricultural Experiment Station Tech. Paper 509.

ANNOUNCEMENT

The color film story of plant diseases entitled, "Design for Abundance," produced by The American Phytopathological Society in celebration of its fiftieth anniversary, is now available for preview.

For purpose of preview, this film can be obtained at no cost from:

Atlas Film Corporation,
1111 South Boulevard,
Oak Park, Illinois

Prof. G. S. Butts,
Dept. of Extension Teaching and Information,
Cornell University,
Ithaca, New York

Mr. D. B. Rosenkrans, Jr.,
Mississippi Extension Service,
State College, Mississippi

Dr. W. C. Reed,
Visual Instruction Dept.,
Oregon State College,
Corvallis, Oregon

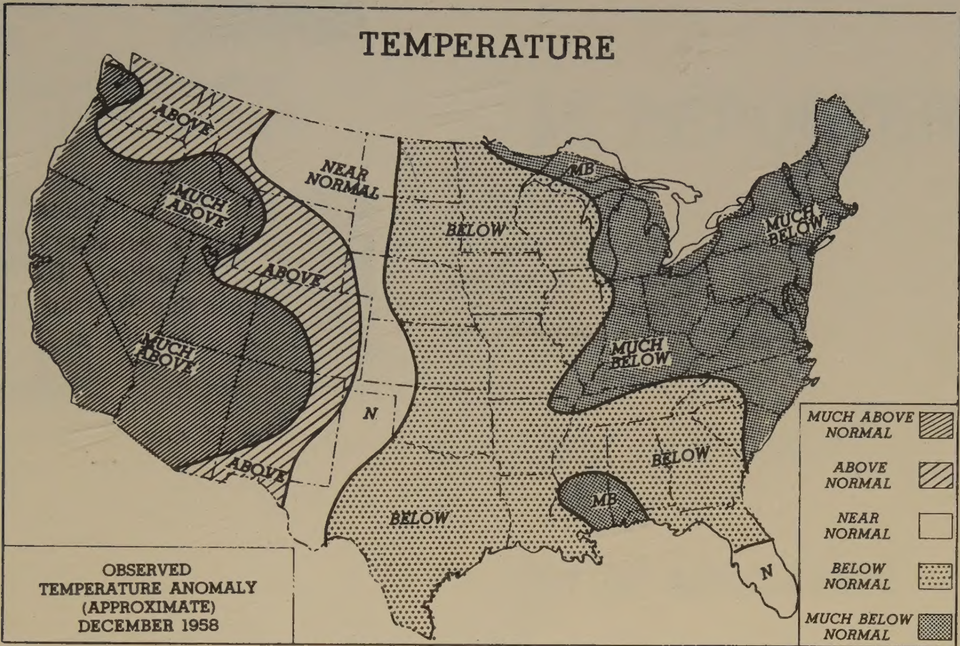
It is available for purchase (23 min., 16 mm., sound, color, $145.00) from: Atlas Film Corporation, 1111 South Boulevard, Oak Park, Illinois.

CORRECTION

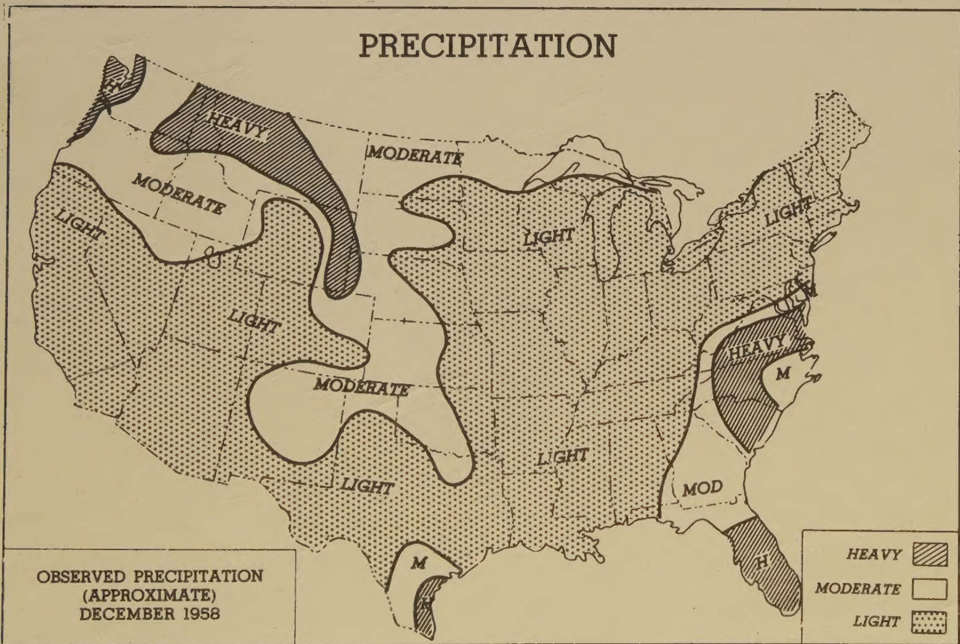
Reference is made to REPORTER article in Vol. 42, pp. 1312-1315, December, 1958, on "Preservation of conidia of *Albugo occidentalis* and *Peronospora effusa*, obligate parasites of spinach." The following literature citation was inadvertently omitted from the article by the authors:

8. WESTER, R. E., CHARLES DRECHSLER, and HANS JORGENSEN. 1958. Effect of freezing on viability of the lima bean downy mildew fungus (Phytophthora phaseoli Thaxt.). Plant Disease Reptr. 42: 413-415.

In the INTRODUCTION of the article the last sentence should read, "Preservation by freezing (1, 2, 6, 8) seemed to offer...."



OBSERVED TEMPERATURE ANOMALY (APPROXIMATE) DECEMBER 1958



OBSERVED PRECIPITATION (APPROXIMATE) DECEMBER 1958

The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.